

Exhibit 90

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Corporate Headquarters
3945 Lakefield Court
Suwanee, GA 30024
(770) 866-3200 FAX (770) 866-3259



**The Analysis of Johnson & Johnson's Historical Product
Containers and Imerys' Historical Railroad Car Samples from
the 1960's to the Early 2000's for Amphibole Asbestos**
2nd Supplemental Report



William E. Longo, Ph.D.

Mark W. Rigler, Ph.D.

Materials Analytical Services, LLC
3945 Lakefield Court
Suwanee, GA 30024

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ATLANTA
Corporate Headquarters
3945 Lakefield Court
Suwanee, GA 30024
(770) 866-3200 FAX (770) 866-3259



The Analysis of Johnson & Johnson's Historical Product Containers and Imerys' Historical Railroad Car Samples from the 1960's to the Early 2000's for Amphibole Asbestos

Supplemental Report

This supplemental report contains the following new information obtained by MAS:

1. In the previous reports, Lee Poye STS samples 20180061-31F (STS 065) and 20180061-31G (STS 065) was assumed to be two samples from the same J&J container STS 065. This assumption was based on that both samples had the same J&J container I.D. of STS 065. Recently we examined container photographs of STS 065 and discovered that the J&J I.D. STS 065 was for two containers in a single package. The 31F sample is for a white STS "Regular" container and for sample 31G, "peach color" STS container that has a "SPICE" label at the top of the container. This new information changed the total number of containers/samples analyzed from 71 to 72 and the total positive samples from 49 to 50. This report was corrected to reflect this information.
2. Correct typographical errors and editing for clarification.
3. This 2nd Supplement Report does not contain any new analytical data.

Overview

Historical J&J Containers

This 2nd supplemental report describes the procedures and methodology used by both MAS and J³ Resources Inc. to analyze 72 separate historical containers and samples of Johnson & Johnson's (J&J) Baby Powder (JBP), Shower to Shower (STS) and Imerys' railroad car cosmetic talcum powder for the possible presence of amphibole asbestos. The J&J and Imerys' containers and samples analyzed for this report were all supplied by both J&J and Imerys from their historical inventory.

The 72 J&J and Imerys-supplied historical cosmetic talcum powder containers/samples analyzed for this report, were chosen from the 1960's, 1970's, 1980's, 1990's and early 2000's.

The 72 product sample set consisted of 57 JBP (with Asian)/STS containers, and 15 historical Imerys' samples that were described as "railroad car" samples. The source of the talcum powder for these historical JBP/STS and Imerys containers/samples came from both the Italian

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(1960's, JBP/STS and Vermont (1960's, 1970's, 1980's, 1990's, early 2000) talc mines. Included in this report are seven Asian Historical JBP samples that MAS analyzed from possibly only the 1980's. The source of the talc that J&J used for these historical Asian samples was from the Dongyang talc mine in Korea.

Of the 57 Historical JBP/STS containers reported here, 34 were JBP (with Asian) and 23 were STS.

Historical Imerys Samples

The additional 15 historical Imerys-supplied railroad car samples incorporated into this supplemental report were chosen from 1989, the 1990's and the early 2000's.

The addition of 15 Imerys' samples brings the total number of both historical containers (JBP/STS) and historical samples (Imerys) that MAS has now analyzed for the MDL to 72. This is in addition to the 35 JBP/STS containers (March 11, 2018 Supplemental Report) that were supplied by both plaintiffs' counsel and MAS.

This now would bring the total number of J&J/Imerys cosmetic talcum powder samples analyzed by MAS to 107.

J³ and MAS' Analysis of Historical STS Samples

Of the 57 historical JBP/STS talcum powder containers that were analyzed and reported here, 41 JBP (with Asian)/STS containers were analyzed by MAS and 16 STS containers (MAS verified by ATEM & PLM) were previously analyzed by Lee Poye of J³ Resources Inc., located in Houston, Texas.

For the Lee Poye ATEM analysis, initially MAS was unable to verify the results of two J³ ATEM STS sample analyses (20180061-63D and 20180061-10D). Both of these samples were reported to contain one asbestos anthophyllite structure in each. These two STS samples were not reported in our November 11, 2018 Supplemental Report since we could not verify if they were either positive or negative for amphibole asbestos.

Since the November 11, 2018 report, MAS has received the 16 STS samples (16 containers) from Lee Poye and has analyzed all of these samples by the PLM/Blount method. The two STS samples (20180061-63D and 20180061-10D) that MAS could not verify by ATEM, were positive for regulated amphibole by the Blount/PLM method.

The two STS containers positive for amphibole asbestos are now included into this supplemental report. Our November 11, 2018 expert report provided analysis of 55 historical J&J product containers, and with the addition of these two now verified (Lee Poye STS product

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containers 20180061-63D and 20180061-10D), this 2nd supplemental report is now providing the analytical results for 57 historical JBP/STS containers.

Also, when MAS analyzed five J³ ATEM non-detect STS samples by the Blount/PLM method, four of these five J³ ATEM non-detects were found to be positive for amphibole asbestos by the Blount/PLM method. The one remaining ATEM non-detect J³ STS sample (20180061-02D), was also found to be a non-detect for asbestos by the PLM/Blount method.

As described in our November 11, 2018 report, MAS sent a number of the historical J&J samples to J³ Resources for both PLM and XRD analysis using the ISO 22262-1 and ISO 22262-3 protocols. For this supplemental report, 19 additional historical J&J samples (18 containers) (M69042, M69248 and M68233) were sent to Lee Poye for XRD analysis using the ISO 22262-3 method.

Cosmetic Talc Analytical Methods

The three principle analytical methods used by both J³ and MAS for the analysis of the 57 J&J cosmetic talc containers were X-ray diffraction (XRD), polarized light microscopy (PLM) and analytical transmission electron microscopy (ATEM). For the 15 individual historical Imerys' railroad car samples, were only analyzed by the PLM (ISO & Blount) and ATEM methods. The Imerys' railroad car samples were not analyzed by XRD. The reasons for this will be discussed later in this report.

The three analytical methods used in this report all have strengths and weaknesses where it is expected, that amount of amphibole asbestos content would be at or below 0.1 wt. %.

XRD

For cosmetic talc the XRD has the advantage of analyzing very large samples as compared to either PLM or ATEM. The disadvantages are 1) poor analytical sensitivity for bulk cosmetic talc samples when the potential amphibole asbestos concentration is typically below 0.1 to 0.3 weight % (wt.%), and 2) XRD cannot determine the crystalline habit (fibrous vs. non-fibrous) of amphibole minerals. However, for the majority these samples, XRD (ISO 22263-3) was used so that a comparison of the results to both PLM and ATEM analysis could be made in this report.

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PLM

The PLM method is primarily used today for the analysis of asbestos-added products where the asbestos-content of these products are typically over 1 % by weight.^{1,2,3}

The strengths of the method are that it can positively identify the different regulated asbestos mineral types and provide a qualitative estimate of the weight percent of asbestos. The primary weaknesses of the method are 1) analytical sensitivity issues for samples that may contain less than 0.1 wt. % of asbestos such as cosmetic talcs and 2) because asbestos fiber and bundle structure resolution in the PLM method is dependent on the wave length of light, asbestos particles must be at least 0.5 μm in the smallest dimension to be visible. Interesting enough, Dr. Walter McCrone stated: *"I have never seen rolled talc plates as fibers"* page 44, 3rd paragraph. For these analysis the ISO 22262-1 PLM method was used.

ATEM

It is well recognized that the use of an analytical transmission electron microscope (ATEM) is the only analytical method with the appropriate sensitivity for the analysis of trace mineral concentrations that can be much less than 0.01 wt. %.

ATEM Strengths are: 1) it can positively identify potential fibrous chrysotile and amphibole asbestos structures by energy dispersive X-ray analysis (EDXA) for mineral fiber chemistry and crystalline structure information by selective area electron diffraction (SAED) and 2) The ATEM provides good morphology information that can, in most cases, distinguish between single fibers and bundles of regulated asbestos fibers.

The primary weakness for ATEM analyses of amphibole asbestos in cosmetic talcs is the sample preparation where overloading issues with the talc particles affects the analytical sensitivity of typical ATEM sample preparation procedures. Increasing analytical sensitivity usually involves the examination of hundreds of TEM grid openings and requires significant hours of TEM instrumentation time. Also, the ATEM is typically biased against detecting very large asbestos bundles that are routinely found by PLM.

¹ ISO 22262-1: 2012E Air Quality Bulk Materials Part 1: Sampling and Qualitative Determination of Asbestos in Commercial Bulk Samples.

² The Asbestos Particle Atlas, Dr. Walter C. McCrone, Director McCrone Research Institute, Ann Arbor Science, 1980.

³ EPA/600/R-93/116.

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(770) 866-3200 FAX (770) 866-3259



Heavy Liquid Separation: PLM and ATEM Method

The concern over analytical sensitivity for amphibole asbestos in cosmetic grade talc was first published in the peer-reviewed literature by A. M. Blount.^{4,5} It was estimated by Dr. Blount that for every 1,000 amphibole particles present there would be approximately 1,000,000 talc particles. To overcome this problem the author described the use of a heavy liquid density separation method that reduced the number of talc particles as compared to the potential presence of amphibole asbestos thereby increasing analytical sensitivity for the PLM analysis of the talc samples.

In addition to increasing the analytical sensitivity of the PLM analysis for cosmetic grade talc using the heavy liquid separation method as published by Blount, the heavy liquid separation method can also be used to substantially increase the analytical sensitivity of the ATEM analysis of cosmetic talc samples as described in the ISO 22262-2 bulk materials method.⁶

Reducing the amount of talc increases the sensitivity of the ATEM analysis and it also increases the amphibole sensitivity by the ATEM method. It would also increase the efficiency of the analyst by eliminating the need to examine hundreds of TEM grid openings to achieve reasonable analytical sensitivity.

References for the use of heavy liquid density separation of cosmetic talc during the sample preparation stage was described first by Dr. Fred Pooley in 1971, the Colorado School of Mines Research Institute in 1973 and by Windsor Minerals, Inc., Dartmouth College in 1974.^{7, 8,9}

⁴ A.M. Blount "Amphibole Content of Cosmetic and Pharmaceutical Talcs", Environ. Health Perspectives, Vol. 94, 1991, pp. 225-230.

⁵ Process Mineralogy IX: The Minerals, Metals and Materials Society, 1990, A.M. Blount "Detection and Quantification of Asbestos and Other Trace Minerals in Powdered Industrial-Mineral Samples", pp. 557-570.

⁶ ISO 22262-2: 2014E Air Quality-Bulk Materials Part 2: Quantitative Determination of Asbestos by Gravimetric and Microscopical Methods.

⁷ March, 1974: to Windsor Minerals, Inc., Windsor, Vermont from R.C. Reynolds, Jr., Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire: "Analysis of Talc Products and Ores for Asbestiform Amphiboles".

⁸ Research and Engineering Center, August 11, 1971 Memo to File. FDA Meeting-Asbestos in Cosmetic Talc, August 3, 1971-Washington, D.C.

⁹ Colorado School of Mines Research Institute "A Procedure to Examine Talc for the Presence of Chrysotile and Tremolite-Actinolite Fibers".

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3945 Lakefield Court
Suwanee, GA 30024
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Over All Summary of Results

J&J and Imerys

The 57 JBP/STS containers (including the 7 historical Asian JBP containers) and the 15 individual Imerys' railroad car samples gives a total of 72 historical containers/samples that were incorporated into this supplemental report.

A summary of these results are as follows;

1. The analysis of 34 historical JBP (with Asian) containers found that 24 were positive or 71 % positive.
2. The analysis of 23 historical STS containers found that 18 were positive or 78 % positive.
3. The analysis of 15 individual Imerys' railroad car samples found that 8 were positive or 53 % positive.

Excluding the seven JBP Asian historical containers would then give a total of 65 JBP/STS & Imerys' containers/railroad car samples analyzed; 44 were positive (68 %) for amphibole asbestos.

A summary of the results excluding the Asian JBP containers:

1. 27 historical JBP container analyses; 18 were positive or 67 % positive.
2. 23 historical STS container analyses; 18 were positive or 78 % positive.
3. 15 individual Imerys' railroad car samples; 8 were positive or 53 % positive.

XRD

All 50 JBP/STS (Italian and Vermont talc mine source) talcum powder samples analyzed by XRD were found to be negative or non-detect by this method. Of the seven Asian JBP containers analyzed, two were positive and one sample was inconclusive. The 15 Imerys' railroad car samples were not analyzed XRD.

PLM

When 56 of the JBP/STS containers and Imerys samples were analyzed by MAS using PLM (ISO 22262-1) method (no heavy liquid density separation), 18 of the samples were positive for regulated amphibole asbestos or 32 % positive.

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The Blount/PLM heavy density method found that out of the 72 JBP/STS and Imerys' containers/samples analyzed, 41 or 57 %, were positive for regulated amphibole asbestos.

For the ISO PLM method the amount of asbestos found for the positive samples were all <0.1 %. The Blount PLM method the amount of asbestos found ranged from <0.1 % to 0.7 %.

ATEM

The ISO 22262-2 ATEM (MAS and Lee Poye verified) analysis showed that in 70 JBP (With Asian)/STS and Imerys' railroad car talcum powder samples, 42 or 60 %, contained detectable amounts of amphibole asbestos fibers and bundles (tremolite solid solution series and or anthophyllite solid solution series). Neither chrysotile nor anthophyllite without iron was detected in any of the ATEM samples.

By ATEM, the amphibole asbestos concentration for the 42 positive JBP/STS and Imerys talcum powder samples ranged from between 4,370 fibers-bundles/gram to 268,000 fibers-bundles/gram of talcum powder.

All of analysis (PLM, Blount/PLM and ATEM), 50 (69 %) of the 72 container/samples were positive for regulated amphibole asbestos.

Two different regulated amphibole asbestos types were found. These were the tremolite asbestos solid solution series amphiboles which includes tremolite, winchite, richterite, and actinolite (only tremolite was detected by ATEM) and the anthophyllite asbestos solid solution series that includes anthophyllite, iron-rich anthophyllite, ferro-anthophyllite, cummingtonite and grunerite. Only iron-rich anthophyllite solid solution series asbestos structures were detected.

As expected, no anthophyllite asbestos (without iron) or chrysotile fibers/bundles were found in any of the 42 positive J&J talcum powder samples we analyzed by ATEM. A more detailed explanation for the lack of anthophyllite (without) iron or chrysotile fiber findings can be found in the Discussion and Conclusion Section of this report.

Fibrous Talc MAS Analysis

In addition to tremolite series and anthophyllite series amphibole asbestos, 42 of the 57 JBP (with Asian)/STS and Imerys' talcum powder samples analyzed by ATEM were observed to contain fibrous talc. A semi-quantitative calculation for the amount fibrous talc for each of the positive ATEM samples was also done. The concentration for each of the fiber talc positive ATEM samples ranged from 290,000 talc fibers per gram to 1,020,000 talc fibers per gram of product.

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The 16 J³ ATEM container analysis did not provide enough information to perform a semi-quantitative fibrous talc calculation, and therefore, was reported as not applicable (NA).

The ISO 22262-1 PLM method found that for the 56 Italian, Vermont and China sourced talc containers/samples analyzed by MAS, 55 (98 %) contained fibrous talc. The Blount/PLM method showed that of 72 analyzed, 20 (28 %) contained fibrous talc.

Materials and Methods

Sample Log-In Procedure

The JBP/STS and Imerys' talcum powder samples that were analyzed by MAS for this report were provided by both Johnson & Johnson and Imerys from their historical sample depository. The J&J historical samples were received by MAS in four separate sets and logged into MAS' sample tracking system and assigned to MAS project numbers as follows; **M68233**, two samples received at MAS on February 9, 2018. **M68503**, 75 samples received at MAS on March 29, 2018. **M69042**, 10 samples received at MAS on July 17, 2018 and **M69248**, seven Asian samples received at MAS on August 21, 2018. The Imerys historical samples were received by MAS in two separate sets and logged into MAS' sample tracking system and were assigned MAS project numbers as follows; **M69751**, 43 samples received at MAS on 12/7/2018 and **M69757**, 37 samples were received at MAS on 12/10/2018.

ISO-22262-1 and 3 PLM/XRD (J³ Resources)

On June 1, 2018, 75 J&J sample splits from M68503 and four spiked samples (tremolite and anthophyllite asbestos) were sent to Lee Poye for PLM and XRD analysis by ISO 22262-1 and 3.

On November 28, 2018, 10 sample splits from M69042, seven sample splits from M69248 (Asian JBP Containers), and four spiked samples (tremolite and anthophyllite asbestos) were sent to Lee Poye for XRD analysis by ISO 22262-3. The results were provided to MAS from J³ in a December 12, 2018 report and the data was added to this supplemental report.

On December 12, 2018, two sample splits from project M68233 were sent to Lee Poye for XRD analysis.

The results were provided to MAS from J³ in a December 20, 2018 report and the data was added to this supplemental report.

Muffle Furnace

Approximately 1 to 2 grams (Sartorius Research Balance) of the 72 talcum powder samples was removed from each of the JBP/STS containers and Imerys samples and placed in a 15 ml glass

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scintillation vials. The scintillation vials were then placed in a Fisher Scientific Iso-temp muffle furnace Model #650 at 400°F for a minimum of 4 hours to remove any organic material.

ISO-22262-1 PLM (MAS)

Approximately 60 to 100 milligrams each of the 56 talcum powder samples were analyzed by the ISO 22262-1 PLM method. Three mounts of the talcum powder sample are placed on two glass slides, a drop of the 1.605 refractive index fluid was placed onto each of the three talcum powder mounts, stirred with the point of a scalpel blade, and then covered with an 18 x 18 mm glass cover slip. The entire area of the three coverslip mounts were examined (972 mm²). Positive identification of amphibole asbestos was done by morphology, refractive indices, elongation, angle of extinction, and birefringence. For positive samples, a visual estimation of the quantity of asbestos observed was based on eye calibration through review of lab generated weight percent standards. Visual calibration was augmented by the use of area percent charts.

PLM/Blount Method

Approximately 60 to 100 mg (Sartorius Research Balance) from each of the 72 JBP/STS and Imerys' muffled talcum powder sample aliquots were placed into individual labeled Eppendorf micro-centrifuge tubes (MCT) (Premium 1.5mL MCT Graduated Tubes Cat. No. 05-408-12).

Density Separation

Approximately 1.2 ml of Heavy Liquid (Lithium heteropolytungstates solution, GeoLiquids, Inc., Cat. No. LST010 with a stated density 2.85 g/cc diluted with distilled water to a density of 2.810 (determined by a VWR Hydrometer model number 34620-1109) was added to the MCT containing the 100 mg of the JBP/STS and Imerys' talcum powder samples and mixed with a disposable mixing rod for 10 to 20 seconds. The combined talc and LST heavy liquid (density 2.810 grams/cc) samples were placed into a vacuum desiccator (JEOL EMDSC-U10A) to remove air bubbles for 3 minutes at a pressure of approximately 8 Torr prior to centrifugation.

The MCT sample tubes were then placed in an Eppendorf micro-centrifuge (Model No. 5415D) set at 7,000 RPM for a total of 10 minutes at room temperature. After removal of the MCT tubes from the centrifuge, the talc/heavy liquid was pipetted off from the top of the centrifuge tube, distilled water was added, mixed and the sample was re-centrifuged as described above. This step was repeated two more times. After the third centrifugation/heavy liquid removal step, the heavy particles were removed from the bottom of the centrifuge tube with a pipette with several drops of water containing the heavy particles then transferred to a glass

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microscope slide and allowed to dry. The heavy particle residue on the glass slide was then analyzed by the ISO 22262-01 PLM method.

ATEM-ISO 22262-2 TEM Sample Preparation

Density Separation

Approximately 20 to 60 mg (Sartorius Research Balance) from the muffled talc sample aliquot was placed into a labeled Eppendorf micro-centrifuge tube (MCT) (Premium 1.5mL MCT Graduated Tubes Cat. No. 05-408-12). Approximately 1.2 ml of Heavy Liquid (Lithium heteropolytungstates solution, GeoLiquids, Inc., Cat. No. LST010 density 2.85 g/cc) was added to the MCT containing the talc samples prepped and mixed with a disposable mixing rod for approximately 10 to 20 seconds. The combined talc and LST heavy liquid samples were then placed into a vacuum desiccator (JEOL EMDSC-U10A) to remove air bubbles for 15 minutes at a vacuum pressure of approximately 8 Torr prior to centrifugation.

The MCT sample tubes were then placed in an Eppendorf micro-centrifuge (Model No. 5415D) set at 9,000 RPM for total of 90 minutes at room temperature. After removal of the MCT tubes from the centrifuge, they were flash frozen in liquid nitrogen and the MCT tip was immediately removed with a pre-cleaned 6 inch steel cleaver into a clean 45 mL flat bottom disposable centrifuge tube. Figure 1 shows the cut area on the MCT tip.

Figure 1:

Cut Line for Removal of MCT Tip



Red line is showing cut area on MCT tip

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Deionized water was added to the centrifuge tube to bring the volume to approximately 45 ml. The 45 ml centrifuge tube was capped and inverted by hand 5 times to distribute the collected material in the bottom of the MCT tip. The 45 ml mixture was then immediately and continuously filtered onto a 25 mm Polycarbonate filter (PC) with a 22µm pore size. After the mixture was filtered, the excess heavy liquid was washed through the filter with the addition of approximately 100 ml of deionized water. The prepared PC filter was placed in a new disposable plastic 47mm petri dish and allowed to dry at ambient room temperature in a HEPA hood for a minimum of 2 hours. The processed PC filter samples were directly prepared onto TEM 100 µm size grids (2 for analysis and 1 for archive) using either the standard TEM filter preparation protocol for MCE filters or for the PC filters.^{10, 11, 12, 13, 14, 15}

ATEM Amphibole Analysis Procedure

JEOL 1200EX ATEMs equipped with either a Noran or an Advanced Analysis Technologies (light element) energy dispersive x-ray analyzer (EDXA) were employed for this analysis. ATEM samples were analyzed at a screen magnification of 20,000X. Amphibole fibers or bundles with substantially parallel sides and an aspect ratio of 5:1 or greater, and at least 0.5µm in length were counted as regulated asbestos fibers and bundles per standard TEM counting rules as described by ASTM D5755, ASTM D5756, ISO 10312, ISO 13794, AHERA (TEM section only) and D7712-11.^{10,11,12,13,14,15}

Positive identification of amphibole asbestos requires EDXA for mineral chemistry confirmation and selected area electron diffraction (SAED) for each amphibole type. At times, amphibole bundles may have a diameter that is too thick to acquire a SAED pattern, then, only the mineral chemistry can be used. For anthophyllite series asbestos, two separate angle SAED were acquired.

¹⁰ D5755-09 "Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Loading.

¹¹ D5756-02 "Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust Loading by Transmission Electron Microscopy for Asbestos Mass Surface.

¹² ISO 10312 1995-05-01, "Ambient Air Determination of Asbestos Fibers-Direct-Transfer Transmission Electron Microscopy Method.

¹³ ISO 13794 1999 07-15, "Ambient Air-Determination of Asbestos Fibres-Indirect-Transfer Transmission Electron Microscopy Method.

¹⁴ U.S. Environmental Protection Agency (USEPA) 1987. Asbestos Hazard Emergency Response Act, 40 CFR Part 763, Appendix A to Subpart E, USEPA, Washington D.C.

¹⁵ D7712-11 "Standard Terminology for Sampling and Analysis of Asbestos."

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Counting Rules

100 grid openings were analyzed for each of the JBP/STS and Imerys talcum powder samples. The 100 grid opening counts were split evenly between two grids.

All amphibole fibers/bundles that meet the above-stated size criteria were recorded on the MAS TEM structure count bench sheets for each sample. Length and width of each amphibole fiber/bundle was recorded and identified. Every amphibole structure identified and counted by the analyst required observation of an EDXA spectra matching the mineral chemistry for that particular amphibole and a SAED amphibole pattern. EDXA spectra and SAED patterns are recorded/saved for every asbestos amphibole structure found in the samples.

Photomicrographs were taken of the amphibole fibers/bundles found from each of the samples that were positive for amphibole asbestos.

Results were reported as either amphibole asbestos fibers/bundles (structures) per gram of talc or in weight percent. Analytical sensitivity/detection limits were reported as structures per gram. The weight percent analytical sensitivity/detection limit was not provided in the November 11, 2018, since the procedure for calculating the detection limit is to use a theoretical mathematical calculation of one arbitrary minimal fiber dimension. Instead of an arbitrary fiber dimension, a more accurate represented fiber size would be to use an average size for all the of detected amphibole fibers structures analyzed by ATEM in these samples. The average amphibole asbestos structure size was 12.1 μm x 1.1 μm , with an aspect ratio of 11:1. For this report, the more accurate weight detection limit was added to the data sets.

Fibrous Talc Estimation

A number of the JBP (with Asian)/STS and Imerys talcum powder samples were found to contain fibrous talc during both types of the PLM analysis as well as the ATEM analysis. A full quantitative analysis of the number of fibrous (asbestiform) talc particles was not done at this time. For the ATEM, a semi-quantitative estimate of the number of fibrous talc particles present in four random grid openings and observed throughout the 100 grid openings was scored as follows:

- 1) Abundant : (>11 fibrous talc particles)
- 2) Common: (4 to 10 fibrous talc particles)
- 3) Trace: (1 to 3 fibrous talc particles)

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This estimation was based on the talc fibers/bundles having at least a 5:1 aspect ratio or greater, at least 0.5µm in length and substantially parallel sides. One representative talc fiber or bundle was recorded (EDXA, SAED and photographed) for each of the samples that contained fibrous talc. Also, the finding of fibrous talc on random grid openings provided an overall estimate of how many talc fibers were on 100 grid openings analyzed for each of the samples.

For both PLM methods a visual estimation was made of the identified talc fibers and was reported as either trace or moderate (common).

Process Laboratory Blanks

For each set of samples that were prepared by the heavy liquid method, one process laboratory blank was prepared with each set of samples. These process blank MCE filters were prepared in the same exact manner as the talc samples (heavy liquid, filtration on MCE/PC filters, etc.) but without any talc material. For the TEM analysis, 100 grid openings were analyzed for each of the process blanks per sample set.

Results

J³ RESOURCES INC. ANALYSIS

XRD ISO 22262-3 Method

J³ Analysis

Lee Poye of J³ Resources analyzed 57 JBP/STS containers by the ISO 22262-3 XRD method. Of the 57 JBP/STS containers analyzed, 54 were non-detects, two were positive, and one was inconclusive by the XRD method.

For 50 JBP/STS containers where the source of the talc was either the Italian or Vermont mines, all were non-detects by XRD. The other seven were Asian historical JBP containers (the source of the talc was from the Korea mine) had two positive and one inconclusive and the other four samples were non-detects. The 15 Imerys railroad car samples were not analyzed by XRD.

A summary of all the XRD results are shown in Tables 7 & 8 to this report.

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PLM ISO 22262-1 Method

J³ Analysis

Using the ISO 22262-1 PLM method, J³ Resources found that out of 38 samples analyzed, all were negative or non-detects. A summary of the J³ results are also shown in Table 8 in this report.

ATEM of Historical J&J Vermont Talc Shower to Shower Talcum Powder

On July 18, 2018 Lee Poye of J³ Resources, Inc. issued a report (to Joe Satterley of the Kazan Law Firm) of his analysis of 16 historical J&J Vermont talc Shower to Shower talcum powder samples that were split by J&J from their historical Shower to Shower (STS) containers that ranged in date from 1978 to 1986.¹⁶

Of the 16 STS containers analyzed by Lee Poye using the ISO 22262-2 heavy liquid TEM method, 11 of the 16 samples (69%) were positive for anthophyllite asbestos (solid solution series) and five samples were below the detection limit of the method. A summary of the 11 positive results are shown in Table 1.

Table 1

J³ TEM Results for Positive Vermont Talc Shower to Shower Samples

Laboratory Control Number	J&J Sample Identification Number	STS Container Year	Mass Fraction Percent Wt.	Anthophyllite Asbestos (f/b) Concentration per g
20180070-07D	2014.001.0397	1978	7.3×10^{-4}	82,370
20180061-37D	STS001	1982	3.0×10^{-5}	9,257
20180061-38D	STS002	1980	3.0×10^{-3}	53,416
20180061-45D	STS009	1982	1.9×10^{-3}	9,000
20180061-52D	STS016	1980 - 1981	4.0×10^{-3}	70,126
20180061-63D	STS027	1980	3.5×10^{-5}	7,419
20180061-65D	STS029	1980 - 1981	9.2×10^{-3}	95,321
20180061-10D	STS044	1980 - 1981	2.6×10^{-5}	12,209
20180061-15D	STS049	1978	1.3×10^{-3}	60,507
20180061-31F	STS065	1986	2.9×10^{-3}	21,964
20180061-31G	STS065	1986	5.2×10^{-4}	29,715

¹⁶ J3 Report for the Analysis of Shower to Shower Talc Samples, July 18, 2018.

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The above results were reported by J³ as a mass fraction or weight percent. The calculations to the corresponding anthophyllite fiber/bundle concentrations per gram was done by MAS using the information provided on the J³ TEM count sheets.

Verification of Lee Poye's STS Results

Lee Poye arrived at MAS on the morning of October 31, 2018 with one TEM grid box that contained the prepared TEM grids for J³ project number JHI898969 for the J&J Vermont Talc STS samples. This information was confirmed by Lee Poye, that the TEM grids he brought to MAS was for the historical STS samples that he had previously analyzed.

In turn, MAS provided Mr. Poye with MAS TEM grid boxes for the 10 historical JBP talcum powder samples (MAS M69042). The MAS verification of the J³ analysis was only for the 11 positive TEM sample analysis, the five sample results that were below the detection limit were not verified by MAS, and those results were accepted as true by MAS.

MAS was able to verify nine of the 11 ATEM positive historical STS talcum powder samples reported by J³. The nine positive MAS verified STS ATEM samples, two non-verified STS positive ATEM samples, and the five samples that were below the ATEM detection limit, were included in this overall report and are identified in summary Tables 3 and 4.

A full report of the MAS verification analysis, verified count sheets, asbestos structure photomicrographs, EDXA and SAED data is provided with this report.¹⁷

The overall summary of the results for the three analytical methods used for the 57 JBP/STS containers and 15 Imerys' historical railroad car samples analyzed for this report are summarized in Tables 2, 3, 4, 5, 6, 7, 8 and 9. These summary tables have been organized by decade from the 1960's (Table 2), 1970's (Table 3), 1980's (Table 4), 1990's (Table 5) early 2000's, (Table 6), Asian (Table 7, XRD only), XRD and PLM (Table 8), and Fibrous (Table 9).

ISO-22262-1 Analysis

The ISO 22262-1 PLM analysis showed that out of the 72 JBP (with Asian)/STS containers and 15 Imerys' railroad car samples analyzed by MAS and J³, 18 containers (25%) had detectable amounts of regulated amphibole asbestos, the rest were either non-detects or contained actinolite/tremolite cleavage fragments that had an aspect ratio of < 3:1.

Results for all 18 positive samples were found to contain <0.1 % asbestos. Also, for these positive ISO PLM samples, both regulated actinolite/tremolite and or anthophyllite asbestos were found.

¹⁷ Verification of Lee Poye's TEM Analysis of J&J's Historical Vermont Talc-Containing Shower to Shower Talcum Powder Samples, November 5, 2018.

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A summary of the MAS & J³ ISO 22262-1 PLM analysis results are shown in Tables 2, 3, 4, 5 and 6 in this report.

Comparison of the J³ ISO PLM to MAS ISO PLM Analysis for the Same Sample Set

Both MAS and J³ analyzed the same 22 J&J/STS talc samples by the ISO22262-1 PLM method. Where all 22 of the J³ ISO PLM results were found to be negative, MAS found that 8 of the 21 were positive. A summary of this data is shown in Table 8.

PLM/Blount Method

The Blount/PLM method showed that out of the 72 historical JBP (with Asian)/STS containers and Imerys' railroad car samples analyzed by MAS, 41 (57%) had detectable amounts of regulated amphibole asbestos and the rest were either non-detects or contained only tremolite/actinolite cleavage fragments that had an aspect ratio that was less than 3:1.

These 72 historical containers/samples analysis by the Blount/PLM also includes the 16 Lee Poye historical STS containers that were sent to MAS from J³ on Nov 14, 2018 and received at MAS on Nov 16, 2018.

Results for 41 positive samples were reported as an estimated weight percent range of from < 0.1% to 0.7 %. Also, for these positive Blount/PLM samples, both regulated actinolite/tremolite and or anthophyllite asbestos was detected.

The summary of the MAS Blount/PLM results are shown in Tables 2, 3, 4, 5, and 6 in this report.

ATEM ISO 22262-2 Method

The ISO 22262-2 ATEM heavy liquid separation method showed that out of the 70 historical JBP/STS containers and Imerys' railroad cars samples, 42 (60 %) contained regulated asbestos fibers and bundles. Two types of asbestos amphiboles were detected in these samples, they were either the tremolite asbestos solid solution series and or the anthophyllite solid solution series asbestos. Only the iron-rich anthophyllite asbestos was detected in the ATEM.

The amphibole asbestos structures per gram of talc ranged from below our analytical sensitivity/detection limit of approximately 3,000 - 9,400 fibers/bundles per gram to an amphibole asbestos concentration that ranged from 4,400 - 268,000 fibers-bundles/gram of talc. Also, for the positive ATEM samples the results were also expressed as a weight percent.

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Tables 2 through 6 also provide the summary of ATEM findings for each of the 42 positive ATEM samples that were detected and the identification of the asbestos type for each of the measured amphibole asbestos fiber or bundles. This data includes length and width of the asbestos structure, individual fiber/bundle aspect ratios, and the average aspect ratio for each sample set.

All MAS and ISO PLM, Blount/PLM, ATEM analytical data, and photo-micrographs can be found in notebooks provided with this report that are labeled Historical 1960's, 1970's, 1980's, 1990's Early 2000's and JBP (with Asian)/STS and Imerys' Analysis.

Each of these notebooks contain ISO PLM and Blount bench sheets and optical photo-micrographs for each sample. ATEM count sheets, EDXA spectra, SAED micrographs, and ATEM photo-micrographs for each of the regulated amphibole asbestos structures analyzed are included.

All the J³ XRD and ISO PLM analyses are summarized in Tables 7 & 8. Also provided in Table 8 is a comparison of the J³ ISO-PLM to the MAS ISO-PLM for the same sample analyses.

Fibrous Talc JBP (with Asian)/STS Containers and Imerys Railroad Car Samples

The MAS ISO 22262-1 PLM analysis showed that fibrous talc was found in 56 of 57 total samples (55 of 55 JBP (with Asian)/STS and Imerys analyzed by this method and of the 72 samples analyzed by the Blount/PLM method, 28 of the samples were positive for fibrous talc.

The MAS ISO 22262-1 and Blount PLM samples had concentrations of fibrous talc that ranged from trace to common (moderate) amounts.

For the MAS ISO 22262-2 ATEM analysis (no J³ ATEM results), 42 of the 56 containers/samples (74%) analyzed contained trace amounts of fibrous talc. The estimated amount of fibrous talc per gram ranged from 290,000 talc fibers to 1,020,000 talc fibers per gram of cosmetic talcum powder.

No attempt was made to determine the amount of talc in 16 J³ STS sample analysis ATEM bench sheets since it was unclear to us regarding the J³ data collecting parameters and the amount of fibrous talc detected in the samples. This data is summarized in Table 9.

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Process Blanks

All of the process blanks that were run with each set of talcum powder samples were found to be negative for any asbestos fiber types. The ATEM bench sheets and summary are provide in a separate document supplied with this report.

Discussion

XRD ISO 22262-3

All of the historical JBP/STS containers, where the source of the talc was either Italian or Vermont were found to be negative or non-detect by XRD. For the seven (7) Asian samples, two (2) of the samples were positive by the XRD analysis and one sample was inconclusive. The source of the talc that J&J used in these Asian products was from the Korean Dongyang talc mine in Korea. This talc mine has been characterized in the past as an asbestiform tremolite asbestos talc mine. The documentation concerning the Dongyang mine Korea talc deposit and J&J's use of the talc from that has been produced to J&J in the *Leavitt* deposition.

The results show that the XRD method for either the Italian or Vermont cosmetic talc samples was inadequate to detect any tremolite or anthophyllite amphiboles at the concentrations found by the other analytical methods used (ISO PLM, Blount PLM and ATEM).

For the Asian historical J&J cosmetic talc samples, two of the seven were positive for amphibole asbestos. When these same samples were analyzed by the ISO-PLM, Blount/PLM and ATEM methods, six of seven samples were found to be positive for tremolite asbestos.

Based on these results there seems to be little value, even as a screening tool, to use XRD for cosmetic talcum powder samples when the source of talc is either from the Italian or Vermont mines. However, if the source of talc is from the Dongyang mine in Korea, there may be some limited value to use XRD as a preliminary screening tool for a tremolitic type talc mine.

Since all 42 Vermont-sourced cosmetic talc samples were found to be negative for amphibole asbestos, there was no useful reason to analyze these additional 15 Imerys railroad car samples by XRD since the source of these Imerys cosmetic talc samples is from the same Vermont talc mines.

MAS PLM-ISO 22262-1 Method

The ISO PLM analysis performed by MAS detected 18 positives out of 56 samples that were analyzed. Many of the samples analyzed contained tremolite/actinolite cleavage fragments that had a typical aspect ratio of less than 3:1. No anthophyllite cleavage fragments were detected in any of the samples. For the positive samples, both regulated tremolite/actinolite and anthophyllite asbestos was detected at an estimated concentration of <0.1 weight percent.

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All of the asbestos structures identified were large bundles that were typically greater than 50 microns long and 10 to 20 microns wide. No individual asbestos bundles were detected in any of these samples with widths less than 5 to 10 microns. However, individual fibers contained in these large bundles could be resolved with dispersive staining. The estimated average aspect ratio of the individual asbestos fibers in the bundles was greater than 20:1.

Lee Poye of J³ Resources analyzed 22 historical JBP/STS by the ISO PLM that were provided by MAS, and their 16 historical Vermont STS samples by this method. All 38 ISO PLM analysis were reported as non-detects.

When the same 21 historical JBP/STS samples were analyzed by MAS, 8 of the samples were found to be positive.

These differing results between the two labs will require further investigation to understand the reason for these differences.

Blount/PLM Method

The Blount /PLM method heavy liquid separation method was able to increase the analytical sensitivity of the PLM analysis as compared to the ISO PLM method without heavy liquid separation. Of the 72 historical JBP (with Asian)/STS containers/samples analyzed by this method, 41 (57 %) were positive for regulated amphibole asbestos. For the positive samples, both regulated actinolite/tremolite and or anthophyllite asbestos were detected at a weight percent concentration for range of between <0.1% to 0.7 %. The estimated average aspect ratio of the individual asbestos fibers in the bundles was greater than 20:1.

When Dr. Blount published her heavy liquid separation PLM results in 1989/1990, one of the samples (sample I) was analyzed for tremolite asbestos. This sample was later determined to be a container of Johnson's Baby Powder.^{3, 4} The source talc used by J&J, for their JBP product at that time (1989-1990), would have been from Vermont.

Our use of Blount PLM method, in particular for the Vermont sourced cosmetic talc samples, shows that Alice Blount was right and that her method increases the sensitivity of the PLM analysis for the detection of amphibole asbestos.

Dr. Blount published the use of the heavy liquid separation method in 1989/1990, however this was not a new technology for the analysis of cosmetic talc by PLM. Historical documents produced by J&J in this litigation shows that J&J was aware of the heavy liquid separation ("preconcentrating") of talc for the detection of asbestos in the early 1970s.⁸ In 1973, a two

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part heavy liquid separations method report, for both chrysotile and tremolite-actinolite fibers, was done by the Colorado School of Mines on behalf of Johnson & Johnson.⁷

For this report, the Colorado School of Mines stated in their Summary and Conclusion section that the heavy liquid concentrates are examined by optical microscopy (PLM), and that "the procedure is capable of detecting fibers present at a level of approximately 10 ppm or less".⁸ A 10 ppm (parts per million) detection limit calculates to a weight percent of 0.001 % which is consistent with our Blount PLM analysis of <0.1 % for positive samples.

In March of 1974, R.C. Reynolds Jr. wrote a report for Windsor Minerals Inc. entitled "Analysis of Talc Products and Ores for Asbestiform Amphiboles".⁹ This method also used heavy liquid separation and PLM analysis. The purpose of the study was to "develop methods for measuring the concentration of asbestiform amphiboles in fine-grained talc products and talc ores". The report concluded that using this method detected 170 ppm (0.017 weight percent) of actinolite in a talc product and 2,300 ppm (0.23 weight percent) of actinolite in the talc ore.

Even though Johnson & Johnson was aware from as early as 1973 that the heavy liquid separation PLM method increased the sensitivity for the detection asbestos in talc, they never incorporated this method for the routine analysis of their talc sources. Even when Dr. Blount published her heavy liquid separation PLM method in 1990, J&J still did not incorporate this more sensitive PLM method for the detection of asbestos in their cosmetic talc products.

It is clear from our data that the use of the Blount/PLM heavy liquid separation method increases the analytical sensitivity for the analysis of cosmetic talc samples like the JBP/STS products as compared to the ISO PLM method. Since some of the ISO 22262-1 PLMs were positive for the same samples that were non-detects by the Blount method, it's recommended that both PLM methods should be used to evaluating cosmetic talc samples for asbestos.

J³ Resources, Inc.

Our ATEM results for the historical JBP/STS samples are in agreement with the J³ Resources, Inc. ATEM for the STS samples that they analyzed. For the nine J³ samples that we verified from their TEM grids, J³ also reported nine positive TEM samples and all contained regulated amphibole asbestos fibers/bundles. This correlates to 100 % agreement between the two labs for those nine samples.

For the 49 asbestos fibers and or bundles reported by J³ in the 9 nine ATEM samples we examined, we verified 48 as regulated asbestos structures. This shows a 98 % validation rate

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between the labs. Additional analysis may in fact increase the overall verification percentage. Also, 90 % of the regulated anthophyllite asbestos structures were bundles.

The two J³ ATEM samples (20180061-65D and 20180061-10D) that MAS did not verify, were verified to contained amphibole asbestos by the Blount PLM method. Even though we did not verify these two J³ samples by ATEM, we did find that these two J&J containers/samples were positive for regulated amphibole asbestos. For this reason, STS samples 20180061-65D and 20180061-10D were added to the overall list of positive 1980s historical J&J STS Vermont sourced talc containers.

ATEM-ISO 22262-2 Method

The ISO 22262-2 heavy liquid talc preparation method for the direct ATEM analysis of approximately 20 to 60 mg of talc on a 25 mm PC filter did not cause any significant overloading of the TEM grids with talc particles. The overall TEM grid particle loading was estimated at approximately 15 to 20 %. This consisted of talc particles and/or fibers as well as detectible amphibole asbestos. The ATEM results showed that out of the 70 JBP/STS and Imerys samples analyzed by ATEM, both the MAS and Lee Poye's analyses, 42 were positive for either the tremolite solid solution series (tremolite, winchite, richterite and actinolite) in this case only tremolite was detected, and or the anthophyllite sold solution series (anthophyllite, iron-rich anthophyllite and cummingtonite) asbestos. Each of the tremolite or anthophyllite asbestos solid solution series amphibole mineral types are regulated asbestos.¹⁸ Only iron-rich anthophyllite sold solution series asbestos structures was detected.

If the same weight of talc (approximately 20 to 60 mg) had been directly filtered onto a 25 mm PC filter, the TEM sample preparations would have been too severely overloaded with talc particles to be analyzed.

The heavy liquid density ATEM sample preparations demonstrated the utility of the ISO 22262-2 talc method by increasing the analytical sensitivity of the typical ATEM bulk talc analysis for the potential detection of amphibole asbestos. For these analyses the analytical ATEM achieved sensitivity/detection limits ranging from approximately 3,000 - 9,400 fibers-bundles/gram of talc. It also increased the analyst's efficiency without talc particle overloading issues.

This TEM talc loading problem vs. analytical sensitivity issued was been solved by the use of the heavy liquid density procedure, and should be the standard protocol for TEM cosmetic talc analysis.

¹⁸ Current Intelligence Bulletin 62: "Asbestos Fibers and Other Elongated Mineral Particles". State of the Science and Roadmap for Research" Revised Edition. NIOSH CIB62-Asbestos.

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As compared to either the XRD or the two PLM methods, the ATEM provides the most sensitive method for the detection of regulated amphibole asbestos in cosmetic talc.

Numerical Structure Count vs. Weight Percent

Our ATEM analysis showed that the asbestos fiber/bundle concentration, in the 41 positive samples ranged from approximately 4,400 to 268,000 fibers-bundles per gram of talcum powder. These positive results were also reported in weight percent that is based on a mathematical calculation. Also the analytical sensitivity or detection limit for the weight percent used here was based on the average size of all amphibole asbestos structures detected (187) in the 41 positive ATEM samples. This average size was determined to be 12.1 μm x 1.1 μm , with an aspect ratio of 11:1.

However, just reporting ATEM weight percent data does not provide any useful information for determining potential airborne exposure to asbestos structures of the bulk talc material being tested. The Introduction to the ISO 10312 Ambient Air TEM Method states the reasoning for this:

"Because the best available medical evidence indicates that the numerical fibre concentration and the fibre sizes are the relevant parameters for evaluation of the inhalation hazards, a fibre counting technique is the only logical approach".

Also, reporting the analytical sensitivity in weight by the ATEM method is very misleading since it is based on the theoretical mathematical calculation of one minimal fiber size which can give a computed analytical sensitivity in the millionths of a percent range. The misleading part of this is that in order to find that one small fiber during the ATEM analysis, you must have a real numerical fiber-bundle concentration per gram of talc for the analysis to possibly find that one fiber, otherwise this ATEM theoretical analytical sensitivity expressed in weight percent is meaningless.

An example of this problem can be found with the 2010 FDA report of the testing of cosmetic talcs that is published on their website. In that report, FDA states a TEM average limit of detection of 0.0000021 % wt. or 2.1×10^6 .¹⁹ However, when the ATEM analytical sensitivity was calculated from actual AMA TEM bench sheets, the numerical fiber concentration needed to find that one fiber was 13,500,000 fibers per/gram of talc.²⁰ A one fiber analytical sensitivity of that magnitude would have caused all of the ATEM analyses reported here to be non-detects.

¹⁹ www.FDA.gov.

²⁰ AMA Analytical Services, Inc. Report of Cosmetic Grade Talc, 2010.

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3945 Lakefield Court
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(770) 866-3200 FAX (770) 866-3259



Crystalline Habit and Asbestiform Definitions

Each of the analytical protocols referenced in this report (PLM and TEM) all have a definition for asbestiform that is some variation of the following statement:

*Asbestiform: specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.*¹³

This definition of asbestiform in these protocols is only a general geological definition that might be used in the field to evaluate a particular commercial asbestos mine site, because the more fibrous, the greater economic value of the mine.

If this wasn't meant to be a general geological definition, then the methods would have incorporated into the counting protocols the procedures necessary for the determination or measurement of either the tensile strength or flexibility of the microscopic asbestos fibers and bundles. Of course, the methods do not measure flexibility or strength since that type of measurement is impossible by either PLM or ATEM. None of these methods even define what high tensile strength is, or how many measurements constitute a population. Interesting enough, as compared to the commercial forms of asbestos (chrysotile, amosite and crocidolite), both tremolite and anthophyllite asbestos have low tensile strength and poor flexibility and yet are regulated asbestos fibers.²¹

Also, the vast majority of the fibrous amphibole asbestos structures reported here were bundles (as defined by parallel fibers in an asbestos structure that are closer than one fiber diameter to each other.

It is unreasonable to think that breaking up a non-fibrous asbestos can form multiple individual fibers all in close proximity and parallel to each other and that meets the definition of a bundle. That is why fibrous mineral bundles have been recognized in the published literature as asbestiform for many years.

In Blount's publication, she states the following:

*"In addition, the tendency to bring down a disproportional number of larger particles has the true asbestiform amphiboles one generally sees some particles showing bundles of fibrils which removes any doubt about the nature of the amphibole".*⁵

²¹ "Asbestos in Ontario, Ontario Department of Mines and Northern Affairs." Industrial Mineral Report 36, 1971.

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Dr. Wiley in her 1999 ASTM International publication stated that the finding of bundles shows that the structure should be considered asbestiform.²²

The total amount of regulated asbestos structures counted in the 42 positive ATEM samples was 187 bundles and fibers. Asbestos bundles, as compared to fibers, was approximately 96 % of the regulated asbestos structures counted in the ATEM positive samples.

By definition, these asbestos bundles are all classified as asbestiform. Nevertheless, all fibers and bundles reported by the ATEM method are regulated asbestos structures regardless of the geological definition for asbestiform.

For the single tremolite or anthophyllite fibers reported here, they all have been verified as to have formed in a fibrous crystalline habit since they are both fibrous and crystalline as well as meet the health based counting rules for regulated asbestos.²³

Aspect Ratio

Another aspect that must be considered is the milling process that is required to produce cosmetic grade talc and how it effects the overall asbestos size distribution and aspect ratios. This milling effects the asbestos size distribution in talcs was first discussed by Rohl, et al. in 1976.²⁴ In their publication the authors discuss how the talc milling process will break large fibers into a new size distribution in the submicroscopic range.

The average aspect ratio of the regulated asbestos tremolite and anthophyllite fibers and bundles measure by our ATEM analysis was approximately 11:1. This average aspect ratio was consistent with Campbell data for milled tremolite and anthophyllite asbestos. Our measured average aspect ratios were also consistent with Blount's data for tremolite asbestos reported in sample I (identified as JBP).^{4, 25}

For just the tremolite asbestos structure aspect ratios reported here, are also consistent with the NIST tremolite asbestos standard, Blount's tremolite asbestos findings for the off the shelf cosmetic talc container she tested, Campbell's milled tremolite asbestos and Langer & Nolan's

²² A.G. Wylie "The Habit of Asbestiform Amphiboles: Implications for the Analysis of Bulk Samples", ASTM Advances in Environmental Measurements Methods for Asbestos, STP 1342, Jan. 2000.

²³ Manual of Mineralogy, Twenty-First Edition, Revised, Cornelis Klein and Cornelis S. Hurlbert, Jr., John Wiley and Sons, 1999.

²⁴ Rohl, et al., "Consumer Talcum and Powders: Mineral and Chemical Characterization", Journal of Toxicology and Environmental Health, 2: pp. 255-284, 1976.

²⁵ Bureau of Mines Information Circular/Dept. of the Interior, Campbell, W.J., Blake, R.L., Brown, L.I., Cather, E.E. and Sjoberg, J.J.: United States Department of the Interior, "Selected Silicate Minerals and Their Asbestiform Varieties" IC 8751 1977.

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published tremolite asbestos aspect ratio of 10.9 to 1. In the Blount publication, it was reported that the average aspect for non-asbestiform tremolite (cleavage fragments) was approximately 2:1.

Asbestiform tremolite/anthophyllite aspect ratio summary is as follows:

1. MDL ATEM analysis: : 11:1
2. Blount : 9:1
3. Campbell : 9:1
4. Langer : 11:1
5. J&J 3/11/2018 : 10:1
6. NIST 1875 Tre. Std. : 10:1

All of these independent laboratory tremolite asbestos aspect ratio data shows that the tremolite and anthophyllite structures detected by our ATEM analysis shows that they are in fact asbestiform.

As anticipated and discussed below, neither chrysotile nor non-iron containing anthophyllite asbestos was found in any of the samples that were analyzed by ISO 22262-02 ATEM analysis.

So Called Background Asbestos

Of the 42 positive ATEM amphibole asbestos samples analyzed by MAS, nine of the JBP/STS talcum powder samples had only one amphibole asbestos fiber or bundle detected in 100 grid openings which represents the analytical sensitivity/limit of detection for this analysis.

Because tremolite/anthophyllite are non-commercial accessory amphibole minerals and are associated with talc, which is known to contain varying amounts of amphibole asbestos such as tremolite or anthophyllite, any positive findings are scientifically valid due to the amphibole minerals present in the talc.

There are no known commercial asbestos-containing products that used tremolite as an added ingredient, and only one specialty product ever used anthophyllite asbestos (corrosive resistant polymer chemical piping used at some chemical processing plants).

Further, there are no commercial amphibole tremolite/anthophyllite mines in North America, and tremolite and anthophyllite asbestos is not routinely analyzed at trace levels by typical commercial TEM laboratories. For these reasons it can be stated that: 1) there are no background air levels of tremolite/anthophyllite that could have interfered with or contaminated our JBP/STS and Imerys talcum sample analysis, and 2) for each set of JBP/STS

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and Imerys talcum samples that were prepared and analyzed at this laboratory a process laboratory blank was prepared simultaneously to determine if there was any possible cross-contamination.^{26,27}

When these process laboratory blanks were analyzed by ATEM, no asbestos, including either tremolite, chrysotile or anthophyllite asbestos structures were found. Therefore, it can be stated that there was no cross-contamination during sample preparation of the JBP/STS talcum powder samples. Also, it is not our expectation that tremolite/anthophyllite asbestos would become a part of these homogenized talc products at a level identified as a matter of contamination prior to our custody of the samples. To do so would be practically impossible.

Also, these historical 72 JBP/STS containers and Imerys railroad samples came from their respective archived facilities. It is reasonable that the talcum powder in either the J&J containers or the Imerys railroad car samples were authentic and original to the specified date of manufacture (J&J containers) or time of product processing (Imerys). That is the talcum powder contained in these historical J&J container samples we analyzed, was the original talcum powder that was put into the container by J&J.

Non-Detects

For the 70 JBP (with Asian)/STS and Imerys talcum powder samples analyzed, ATEM results for 28 JBP/STS and Imerys talcum powder samples were less than the limit of detection of approximately 3,000 to 9,400 amphibole fibers/bundles per gram of talc. This result cannot be characterized to mean the samples do not contain amphibole asbestos. Rather, it can only be said that if there is any amphibole asbestos present, the number of fiber and bundles per gram of talc are at less than the detection limit for the ISO 22262-2 heavy liquid separation ATEM analysis used by this laboratory.

Chrysotile and Anthophyllite

As anticipated, neither chrysotile nor non-iron containing anthophyllite asbestos was found in any of the 70 samples that were analyzed by the ISO 22262-02 ATEM analysis. However, iron-rich anthophyllite was detected by ATEM because of its increased density.

²⁶ R.F. Dodson, M.F. O'Sullivan, D.R. Brooks and J.R. Bruce, "Asbestos Content of Omentum and Mesentery in Non-occupationally Exposed Individuals", *Toxicology and Industrial Health*, 2001: 17: pp. 138-143.

²⁷ R.J. Lee, D.R. Van Orden, "Airborne Asbestos in Buildings", *Regulatory Toxicology and Pharmacology*, 50 (2008) pp. 217-225.

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As with the ATEM method used here, the Blount PLM also uses heavy liquid separation in the sample preparation methodology.

The following is an explanation for the ATEM and Blount PLM chrysotile and anthophyllite results.

ATEM Chrysotile Separation

The ATEM heavy liquid method is specific for the asbestos tremolite solid solution series and the iron-rich anthophyllite solid solution series. The reason for this is that the heavy liquid solutions used for ATEM talc separation process had a density of 2.85 g/cm³. Therefore, any minerals with a similar density or lower would not be separated by this method such as chrysotile, which has a density of between 2.5 to 2.6 g/cm³.²⁸ The density for chrysotile is 0.020 g/cm³ to 0.025 g/cm³ less than the heavy liquid density used for the ATEM method and therefore, chrysotile asbestos would likely not be separated during JBP/STS and Imerys talcum sample preparation process.

As with the chrysotile non-detects reported here and in well over a hundred cosmetic talc analyses performed by MAS, the ATEM heavy liquid method has never detected chrysotile asbestos in the talcum powder, nor would we expect to have a positive result for chrysotile.

ATEM Anthophyllite Solid Solution Series Separation

The density of anthophyllite ranges from 2.85 to 3.20 g/cm³. This range of densities is primarily due to the addition of iron (Fe) into the chemical structure. For example, anthophyllite is part of a solid solution series (anthophyllite, iron-rich anthophyllite, ferro-anthophyllite, cummingtonite and grunerite) with a chemical formula of Mg₇Si₈O₂₂(OH)₂ to approximately Fe₇Mg₅Si₈O₂₂(OH)₂. Without Fe being present, the density of anthophyllite would be at the lower end of the density gradient of 2.85 g/cm³. Again, since anthophyllite is a solid solution series, the amount of iron atoms that can be substituted into the molecular formula of anthophyllite depends on the iron content of the surrounding rocks. This iron atom substituted could be 0, 1, 2 or higher which accounts for the range of anthophyllite densities described here.

With a low to non-iron anthophyllite density of approximately 2.85 to 2.86 or 2.87 g/cm³, which is the same or very close as the heavy liquid used for the ATEM analysis, one would not expect much separation of this type of either low-iron or non-iron containing anthophyllite from the

²⁸ Manual of Mineralogy, Twenty-First Edition, Revised, Cornelis Klein and Cornelis S. Hurlbert, Jr., John Wiley and Sons, 1999.

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talcum powders using the ISO 22262-2 ATEM method and typically would not be detected by our analysis if present.

As expected, all of the anthophyllite series asbestos structures detected in these talcum powder samples by ATEM were iron-rich; no low iron or non-iron anthophyllite was detected in any of the ATEM samples. For the Vermont talc sourced samples, only three samples contained detectable amounts tremolite series asbestos fibers/bundles. However, this does not mean actinolite/tremolite is not present in significant concentrations in the Vermont talc mines. The ISO 22262-2 and Blount/PLM analysis detected regulated actinolite/tremolite asbestos in 30 of the JBP/STS containers and Imerys railroad car samples. These results is further verification of the utility of using both PLM (with and without heavy liquid separation) and ATEM for analyzing cosmetic talc samples.

Blount PLM Separation

As described above, the ATEM detected only iron-rich anthophyllite asbestos primarily in the Vermont-sourced talcum powder samples which is consistent with the Blount PLM results. Comparing the type of asbestos detected (tremolite and anthophyllite) between the Blount PLM and ATEM analysis where the same sample is positive by both methods, the asbestos types found (either anthophyllite and or actinolite/tremolite) can be different between the two as already discussed in this report.

For example, the analysis for the historical JBP/STS and Imerys samples, showed a number of samples where the only type of asbestos detected by ATEM was the iron-rich anthophyllite, while the Blount PLM not only detected the anthophyllite but also detected actinolite/tremolite. This amphibole asbestos detection difference between the two methods may at times be a function of the different heavy liquid densities used for the Blount/PLM and ATEM protocols.

The Blount PLM protocol specifies a heavy liquid density of 2.810 g/cm^3 as compared to the ISO 22262-2 ATEM method that uses a heavy liquid density of 2.85 cm^3 . This difference of 0.04 g/cm^3 is lower than the density of a low to non-iron anthophyllite. This lower density liquid used in the Blount PLM method would likely be more efficient in separating out the tremolite than the higher density liquid used by the ATEM method. Quite simply, the actinolite/tremolite structures would sink faster in the lower density liquid used by the Blount/PLM method. Also, the lower density liquid would be more efficient in separating out the low to non-iron anthophyllite asbestos.

This difference in the heavy liquid density between the two methods maybe explain why the number of positive Blount/PLMs for amphibole asbestos and the corresponding ATEM amphibole asbestos analysis were non-detect.

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This density difference coupled with the ATEM's bias to the large amphibole asbestos bundles detected by the PLM method shows how important it is to use both of these methods when analyzing cosmetic talc samples.

These overall results are both consistent with and validates our earlier March 11, 2018 Supplemental JBP/STS Report and subsequent analysis of plaintiffs' personal JBP/STS containers.

However, for our testimony, we will only be relying on this report and any future supplemental reports involving the analysis of historical JBP/STS and Imerys containers and samples except for the earlier two JBP samples used in both our Below the Waist and Baby powdering studies.

These results are also consistent with MVA's analysis of talc ore samples from both the Italian and Vermont talc mines where originally the samples were collected by or on behalf of defendant experts.^{29, 30}

Also, our analytical results are consistent with the historical analysis of both Johnson & Johnson's product samples as well as the analysis of talc ore from both the Italian and Vermont mines that have been performed in the past.^{31,32,33,34,35,36,37,38,39,40}

In addition to the above references, we are also relying on the current MAS Johnson & Johnson reliance document list that contains 102 references.⁴¹

²⁹ D.R. Veblen and C.W. Burnham, "New Biopyriboles Chester, Vermont: I. Descriptive Mineralogy", *American Mineralogist*, 63: 1000-1009, 1978.

³⁰ R.L. Virta, "The Phase Relationship of Talc and Amphiboles in a Fibrous Talc Sample, Bureau of Mines Report of Investigations 8923, United States Department of the Interior, 1985.

³¹ November 26, 1990 McCrone Environmental Services Report to Michael J. Keener from Kent Sprague concerning Samples CWM 90-28, 9-29 and 90-30

³² New Reagent Systems-Plant Trial at Windsor Minerals, Inc.

³³ March, 1974 Memo to: Windsor Minerals, Inc., Windsor, Vermont From R.C. Reynolds, Jr. Department of Earth Sciences, Dartmouth College, New Hampshire

³⁴ Forensic Analytical: Quantitative Analysis Report, Asbestos in Bulk Material.

³⁵ May 15, 1984 MSHA visit to Cyprus Industrial Minerals Company, South Plainfield Mill.

³⁶ Nov. 19, 1975 McCrone Assoc., Inc. Letter to Mr. Vernon Zeitz from Gene Grieger concerning talc orr sample analysis.

³⁷ Env. Consultant Report to Johnson & Johnson, April 1, 1977

³⁸ EMV Consultant Report to Johnson & Johnson, April 1, 1977

³⁹ Jan. 30, 1987 to J.A. Molnar and R.N. Miller from Joseph Schmidt Talc Analysis.

⁴⁰ March 14, 1988 to Mathew A. Nunes from Al Dickey, R.J. Lee Group Ref: Talc Samples 879-57 Talc L.

⁴¹ Johnson & Johnson Reliance and Reviewed Documents (95).

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The ATEM and ISO PLM analysis also showed that the majority of the JBP/STS talcum powder samples contained fibrous (asbestiform) talc as compared to the platy talc that is present in all of JBP/STS and Imerys talcum powder samples. It has been reported by others that fibrous talc is a geological metamorphic transformation of anthophyllite to fibrous talc.^{42,43}

Conclusion

All Italian or Vermont talc sourced samples that were analyzed by XRD for asbestos were found to be negative or non-detect. These results show that the XRD method is not a useful tool at all for analyzing cosmetic talc samples (Italian or Vermont sourced talc) for the presence of asbestos amphiboles. Both the ISO and Blount PLM methods have better analytical sensitivities than XRD for these types of samples. It would be highly recommended that the Stimuli Group drop any consideration of using the XRD for their rewrite of USP 40 method.⁴⁴

The use of the ISO 22262-1 PLM analysis was not as sensitive as the Blount PLM method, but both methods have their strengths and weakness. On one hand the Blount PLM method has higher sensitivity, but is limited by the type of anthophyllite asbestos it can detect. The ISO PLM has lower sensitivity, but can detect the entire anthophyllite solid solution series. Also, these two PLM methods can detect the very large bundles that are typically missed by the ATEM analysis. There are few examples where the sample was positive by PLM and negative by ATEM.

It is recommend then that both the ISO PLM and the Blount method should be used as a screening tool for cosmetic talc analysis. Negative samples should then be required to be analyzed by the heavy liquid density ATEM method, which is still the best tool for these types of analysis.

Our ATEM analysis showed that the Italian and Vermont talc mines have a very distinct asbestos type profile from each other when analyzed by this method. The historical samples from the Italian mine contained primarily regulated tremolite asbestos fibers/bundles while the Vermont mine contained primarily anthophyllite asbestos. However, for the MDL samples that contained Vermont sourced talc, the PLM results show that only six positive samples contained anthophyllite only, the rest of the positive PLM samples, for the two methods, had detectable amounts of regulated actinolite/tremolite asbestos. These results show that anthophyllite asbestos maybe more prevalent in Vermont talc when analyzed by ATEM, but significant concentrations of actinolite/tremolite asbestos is also present as shown in the PLM analysis.

⁴² MVA Report: MVA11730 "Investigation of Italian Talc Samples for Asbestos", August 1, 2018.

⁴³ MVA Report: MVA12588 "Investigation of Talc Samples for Asbestos" April 23, 2018.

⁴⁴ Stimuli to the Revision Process-Modernization of Asbestos Testing in USP Talc.

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3945 Lakefield Court
Suwanee, GA 30024
(770) 866-3200 FAX (770) 866-3259



It is clear from these results that the three talc mines (Italian, Vermont and Korean) J&J used to manufacture their historical talcum powder products all contain asbestiform/regulated amphibole asbestos structures.

These overall results are both consistent and validates our earlier March 11, 2018 Supplemental JBP/STS Report and subsequent analysis of plaintiffs' personal JBP containers.


The most sensitive analytical method was ATEM with the ISO 22262-02 heavy liquid separation. It detected 42 positive samples out of the 70 JBP/STS and Imerys' talcum powder samples with a range in concentration of from approximately 4,400 fibers-bundles/gram to 268,000 fibers-bundles/gram of talc. Both tremolite series and anthophyllite series regulated asbestos were found in these samples.

There was a total of 50 positive containers (ATEM and PLM combined) out of the 72 tested that gave an overall 69 % positive result for the historical JBP/STS containers and Imerys' railroad car samples that were tested for this report.

These results are also consistent with our past analysis of Johnson & Johnson cosmetic talc samples that contained tremolite and anthophyllite regulated asbestos fibers, and with MVA's analysis of both the Italian and Vermont talc mine ore samples.

Based on the results of our analysis, it is our opinion that individuals who used Johnson & Johnson talcum powder products (Johnson's Baby Powder and Shower to Shower) in the past would have, more likely than not, been exposed to significant airborne levels of both regulated amphibole asbestos and fibrous (asbestiform) talc.


William E. Longo, Ph.D.
President


Mark W. Rigler, Ph.D.
Chief Science Officer and Senior Consultant

ATLANTA
 Corporate Headquarters
 3945 Lakefield Court
 Suwanee, GA 30024
 (770) 866-3200 FAX (770) 866-3259



Table 2

**Summary of Results for Johnson & Johnson's
 1960's Historical JBP & STS Samples**

MAS Sample Number	Client Sample ID	Year of Mnfr.	Amphibole Asbestos Structures/g	Amphibole Asbestos wt. %	Analytical Sensitivity Structures/g	ISO PLM wt. %	Blount PLM wt. %
M68503-010 JBP	2018-0060-04 JBP 167	1960	31,400	0.00056	8,500	NAD	<0.1 Trem/Act
M68503-009 JBP	2018-0060-03 JBP 166	1962	17,700	0.0000057	8,800	NAD	<0.1 Trem/Act
M68503-024 JBP	2018-0060-76 JBP 119	1963	<8,972	<0.0000268	9,000	NAD	NAD
M68503-004 JBP	2018-0056-25 JBP 232	1964	<2,990	<0.0000268	3,000	<0.1 Trem/Act	NAD
M68503-014 JBP	2018-0060-20 JBP 183	1965	17,300	0.000044	8,700	NAD	NAD
M68503-011 JBP	2018-0060-06 JBP 169	1966	<6,072	<0.0000268	6,100	NAD	NAD
M68503-027 STS	2018-0061-09 STS 043	1966	<2,998	<0.0000268	3,000	NAD	NAD
M68503-019 JBP	2018-0060-44 JBP 087	1967	8,930	0.000045	8,900	NAD	NAD
M69042-003 JBP	20180056-31 JBP 238	1967	18,000	0.0000033	9,000	NAD	NAD
M69042-005 JBP	20180060-25 JBP 188	1967	<8,740	<0.0000268	8,700	NAD	NAD
M69042-006 JBP	20180060-49 JBP 092	1967	<5,932	<0.0000268	5,900	NAD	NAD
M69042-007 JBP	20180060-50 JBP 093	1967	<5,930	<0.0000268	5,900	NAD	NAD
M68503-038 JBP	2018-0061-40 STS 004	1968	<3,045	<0.0000268	3,050	NAD	NAD
M68503-026 STS	2018-0061-08 STS 042	1969	268,000	0.0064	8,650	<0.1 Trem/Act	<0.1 Trem/Act

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3945 Lakefield Court
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(770) 866-3200 FAX (770) 866-3259



M68503-010

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	7.0	0.7	10.0	Bundle	Tremolite
-2	12.0	0.9	13.3	Bundle	Tremolite
-3	20.0	3.5	5.7	Bundle	Tremolite
-4	3.7	0.5	7.4	Bundle	Tremolite

Average Aspect Ratio: 9.1

M68503-009

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	3.8	0.72	5.3	Bundle	Tremolite
-2	3.5	0.42	8.3	Bundle	Tremolite

Average Aspect Ratio: 6.8

M68503-014

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	8.6	1.3	6.6	Bundle	Tremolite
-2	7.9	0.84	9.4	Bundle	Tremolite

Average Aspect Ratio: 8.0

M68503-019

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	20.0	1.0	20.0	Bundle	Anthophyllite

Average Aspect Ratio: 20.0

M69042-003

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	4.52	0.44	10.3	Bundle	Tremolite
-2	3.4	0.42	8.1	Bundle	Anthophyllite

Average Aspect Ratio: 9.2

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Suwanee, GA 30024
(770) 866-3200 FAX (770) 866-3259



M68503-026

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	7.1	0.4	17.8	Bundle	Tremolite
-2	10.6	1.8	5.9	Bundle	Tremolite
-3	3.1	0.23	13.5	Fiber	Tremolite
-4	7.6	0.8	9.5	Bundle	Tremolite
-5	3.2	0.5	6.4	Bundle	Tremolite
-6	7.3	1.2	6.1	Bundle	Tremolite
-7	7.3	0.7	10.4	Bundle	Tremolite
-8	9.8	1.8	5.4	Bundle	Tremolite
-9	4.3	0.8	5.4	Bundle	Tremolite
-10	7.0	0.8	8.8	Bundle	Tremolite
-11	7.4	1.1	6.7	Bundle	Tremolite
-12	13.3	0.7	19.0	Bundle	Tremolite
13	3.7	0.45	8.2	Bundle	Tremolite
-14	3.4	0.6	5.7	Bundle	Tremolite
-15	3.2	0.23	13.9	Bundle	Tremolite
-16	30.8	4.0	7.7	Bundle	Tremolite
-17	2.8	0.5	5.6	Bundle	Tremolite
-18	7.9	0.92	8.6	Bundle	Tremolite
-19	7.5	0.8	9.4	Bundle	Tremolite
-20	3.9	0.6	6.5	Bundle	Tremolite
-21	4.1	0.6	6.8	Bundle	Tremolite
-22	3.0	0.46	6.5	Bundle	Tremolite
-23	24.4	3.0	8.1	Bundle	Tremolite
-24	6.5	1.1	5.9	Bundle	Tremolite
-25	8.6	0.92	9.3	Bundle	Tremolite
-26	27.6	3.7	7.5	Bundle	Tremolite
-27	18.4	2.3	8.0	Bundle	Tremolite
-28	75.9	4.6	16.5	Bundle	Tremolite
-29	9.2	1.4	6.6	Bundle	Tremolite
-30	4.6	0.7	6.6	Bundle	Tremolite
-31	6.9	1.0	6.9	Bundle	Tremolite

Average Aspect Ratio: 8.7

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Table 3
Summary of Results for Johnson & Johnson's
1970's Historical JBP & STS Samples

MAS/J ³ Sample Number	Client Sample ID	Year of Mnfr.	Amphibole Asbestos Structures/g	Amphibole Asbestos wt. %	Analytical Sensitivity Structures/g	ISO PLM wt. %	Blount PLM wt. %
M68503-005 JBP	2018-0056-30 JBP 237	1970	<8,778	<0.0000268	8,780	NAD	NAD
M69042-009 JBP	20180060-68 JBP 111	1970	<6,371	<0.0000268	6,370	<0.1 Trem/Act	NAD
M68503-029 JBP	2018-0061-17 STS 051	1971	<8,417	<0.0000268	8,400	NAD	NAD
M68503-021 JBP	2018-0060-54 JBP 097	1972	<5,918	<0.0000268	5,920	NAD	NAD
M68503-023 JBP	2018-0060-64 JBP107	1973	8,760	0.000017	8,730	<0.1 Anth	<0.1 Anth
M68503-028 STS	2018-0061-12 STS 046	1974	17,500	0.000098	5,800	NAD	<0.1 Anth
02D STS	20180061-02D STS 1611A	1975	<9,400	<0.0000268	9,400	P ³ -NAD	NAD
M69042-001 JBP	20180056-02D JBP 209	1975	22,400	0.000232	4,470	<0.1 Trem/Act <0.1 Anth	<0.1 Trem/Act
M68503-046 STS	2018-0061-57 STS 021	1975	<5,863	<0.0000268	5,900	NAD	NAD
M68503-042 STS	2018-0061-49 STS 013	1976	23,600	0.0024	5,890	<0.1 Trem/Act <0.1 Anth	<0.1 Trem/Act
M68233-001 JBP	2018-0015-01A1 JBP 084	1978	7,240	0.00001	7,240	<0.1 Trem/Act	<0.1 Trem/Act
M68233-002 JBP	2018-0015-01A2 JBP 084	1978	22,130	0.00023	7,400	<0.1 Trem/Act	<0.1 Trem/Act
M68503-057 JBP	2018-0070-10 2014.001.0612JBP	1977	8,360	0.000038	8,360	<0.1 Trem/Act <0.1 Anth	NAD
M68503-020 JBP	2018-0060-53 JBP 096	1978	34,800	0.000053	8,690	<0.1 Trem/Act <0.1 Anth	<0.1 Trem/Act
M69042-002 JBP	20180056-06 JBP 213	1978	63,800	0.00048	9,120	<0.1 Trem/Act <0.1 Anth	<0.1 Trem/Act <0.1 Anth
M69042-004 JBP	20180056-34 JBP 241	1978	18,000	0.000012	6,020	<0.1 Trem/Act <0.1 Anth	<0.1 Trem/Act <0.1 Anth
M69042-008 JBP	20180060-67 JBP 110	1978	18,100	0.00086	6,020	<0.1 Anth	<0.1 Anth
07D STS	20180070-07D 2014.001.0397	1978	82,000	0.00073	9,100	J ³ -NAD	0.2 Trem/Act 0.5 Anth
15D STS	20180061-15D STS 049	1978	61,000	0.0013	8,700	J ³ -NAD	0.3 Trem/Act
50D STS	20180061-50D STS 1605A	1978	<9,300	<0.0000268	9,300	J ³ -NAD	<0.1 Anth
M68503-059 JBP	2018-0070-16 JBP 2014.001.1363	1979	17,100	0.00024	8,560	<0.1 Trem/Act <0.1 Anth	<0.1 Trem/Act <0.1 Anth

NAD: No asbestos detected J³NAD: Samples analyzed by Lee Poye

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3945 Lakefield Court
Suwanee, GA 30024
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**M68503-023**

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	12.0	0.8	15.0	Bundle	Anthophyllite

Average Aspect Ratio: 10.7**M68503-028**

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	18.8	1.8	10.4	Bundle	Anthophyllite
-2	5.7	0.4	14.3	Bundle	Anthophyllite
-3	6.0	0.9	6.7	Bundle	Anthophyllite

Average Aspect Ratio: 10.5**M69042-001**

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	14.4	0.4	36.0	Fiber	Anthophyllite
-2	2.3	0.4	5.8	Fiber	Anthophyllite
-3	15.7	2.0	7.9	Bundle	Anthophyllite
-4	10.0	0.2	50	Fiber	Anthophyllite
-5	22.5	2.5	9	Bundle	Anthophyllite

Average Aspect Ratio: 21.7**M68503-042**

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	19.0	2.0	9.5	Bundle	Anthophyllite
-2	29.0	2.0	14.5	Bundle	Anthophyllite
-3	6.7	0.8	8.4	Bundle	Anthophyllite
-4	40.0	6.0	6.7	Bundle	Anthophyllite

Average Aspect Ratio: 9.8**M68233-001**

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	6.8	0.9	7.6	Fiber	Anthophyllite

Average Aspect Ratio: 7.6

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M68233-002

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	27.7	0.7	36.7	Bundle	Anthophyllite
-2	16.4	2.6	6.3	Bundle	Anthophyllite
-3	7.6	0.5	15.2	Fiber	Anthophyllite

Average Aspect Ratio: 19.4

M68503-057

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	8.0	1.5	5.3	Bundle	Tremolite

Average Aspect Ratio: 5.3

M68503-020

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	8.5	0.42	20.2	Bundle	Anthophyllite
-2	2.7	0.44	6.1	Bundle	Tremolite
-3	4.62	0.62	7.5	Bundle	Anthophyllite
-4	21.1	0.98	21.5	Bundle	Anthophyllite

Average Aspect Ratio: 13.8

M69042-002

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	35.4	1.8	19.7	Bundle	Anthophyllite
-2	12.4	1.1	11.3	Bundle	Anthophyllite
-3	6.4	1.1	5.8	Bundle	Anthophyllite
-4	6.0	0.7	8.6	Bundle	Anthophyllite
-5	34.5	1.1	31.4	Bundle	Anthophyllite
-6	11.5	1.2	9.6	Bundle	Anthophyllite
-7	11.5	1.0	11.5	Bundle	Anthophyllite

Average Aspect Ratio: 14.0

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3945 Lakefield Court
Suwanee, GA 30024
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M69042-004

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	13.4	0.4	33.5	Fiber	Anthophyllite
-2	4.2	0.38	11.1	Bundle	Anthophyllite
-3	13.4	0.63	21.3	Bundle	Anthophyllite

Average Aspect Ratio: 21.9

M69042-008

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	3.9	0.5	7.8	Bundle	Anthophyllite
-2	7.8	1.5	5.2	Bundle	Anthophyllite
-3	5.3	0.5	10.6	Bundle	Anthophyllite

Average Aspect Ratio: 7.9

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Corporate Headquarters
3945 Lakefield Court
Suwanee, GA 30024
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07D

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	3.5	0.25	14	Fiber	Anthophyllite
-2	6.0	0.4	15	Bundle	Anthophyllite
-3	7.5	0.2	37.5	Bundle	Anthophyllite
-4	11.0	0.6	18.3	Bundle	Anthophyllite
-5	4.0	0.25	16	Bundle	Anthophyllite
-6	14.0	1.1	12.7	Bundle	Anthophyllite
-7	8.5	0.4	21.3	Bundle	Anthophyllite
-8	9.0	0.7	12.9	Bundle	Anthophyllite

Average Aspect Ratio: 18.5

15D

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	6.6	0.7	9.4	Bundle	Anthophyllite
-2	5.2	0.22	23.6	Bundle	Anthophyllite
-3	20.3	0.92	22.1	Bundle	Anthophyllite
-4	27.0	1.5	18	Bundle	Anthophyllite
-5	5.9	0.22	26.8	Fiber	Anthophyllite

Average Aspect Ratio: 20.0

M68503-059

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	12.0	0.4	30.0	Bundle	Anthophyllite
-2	17.0	2.5	6.8	Bundle	Anthophyllite

Average Aspect Ratio: 18.4

ATLANTA
 Corporate Headquarters
 3945 Lakefield Court
 Suwanee, GA 30024
 (770) 866-3200 FAX (770) 866-3259



Table 4
Summary of Results for Johnson & Johnson's
1980's Historical JBP & STS Samples

MAS/J ³ Sample Number	Client Sample ID	Year of Mnfr.	Amphibole Asbestos Structures/g	Amphibole Asbestos wt. %	Analytical Sensitivity Structures/g	ISO PLM wt. %	Blount PLM wt. %
10D STS	20180061-10D STS 044	1980	N/A	N/A	N/A	J ³ -NAD	0.2 Tre/Act <0.1 Anth
38D STS	20180061-38D STS 002	1980	53,000	0.003	7,600	J ³ -NAD	0.2 Tre/Act 0.2 Anth
63D STS	20180061-63D STS 027D	1980-1981	N/A	N/A	N/A	J ³ -NAD	0.2 Tre/Act 0.2 Anth
52D STS	20180061-52D STS 016	1981	70,000	0.004	7,800	J ³ -NAD	0.2 Tre/Act 0.5 Anth
65D STS	20180061-65D STS 029	1981	95,000	0.0092	7,300	J ³ -NAD	0.2 Tre/Act 0.2 Anth
37D STS	20180061-37D STS 001	1982	9,300	0.00005	9,300	J ³ -NAD	<0.1 Tre/Act <0.1 Anth
45D STS	20180061-45D STS 009	1982	9,000	0.0019	9,000	J ³ -NAD	<0.1 Tre/Act
51D STS	20180061-51D STS 1606A	1982	<9,400	N/A	9,400	J ³ -NAD	<0.1 Tre/Act
66D STS	20180061-66D STS 1610A	1982	<9,400	N/A	9,400	J ³ -NAD	0.1 Tre/Act
21D STS	20180061-21D STS 1614A	1983	<8,300	N/A	8,300	J ³ -NAD	<0.1 Tre/Act <0.1 Anth
M68503- 001 JBP	2018-0051-34 JBP 294	1984	18,700	0.000036	6,240	<0.1Tre/Act	<0.1 Tre/Act
M69042- 010 JBP	2018-0070-86 2014.001.5102 JBP	1985	12,500	0.000035	6,200	<0.1Tre/Act	<0.1 Anth
31F STS	20180061-31F STS 065	1986	22,000	0.0029	7,300	J ³ -NAD	0.3 Tre/Act < 0.1 Anth
31G STS	20180061-31G STS 065	1986	30,000	0.00052	7,500	J ³ -NAD	0.7 Tre/Act
M69751- 037 Imerys	20180314-03 Imerys	1989	59,000	0.000089	4500	<0.1 Tre/Act	<0.1 Tre/Act <0.1 Anth

NAD: no asbestos detected. J³NAD: Samples analyzed by Lee Poye.

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38D

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	3.2	0.6	5.3	Bundle	Anthophyllite
-2	3.6	0.7	5.1	Bundle	Anthophyllite
-3	18.9	1.5	12.6	Bundle	Anthophyllite
-4	6.0	0.9	6.7	Bundle	Anthophyllite
-5	6.2	1.1	5.6	Bundle	Anthophyllite
-6	3.5	0.4	8.9	Fiber	Anthophyllite
-7	6.0	0.3	20.0	Bundle	Anthophyllite
-8	3.1	0.25	12.4	Bundle	Anthophyllite

Average Aspect Ratio: 9.6

52D

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	46.5	1.5	31	Bundle	Anthophyllite
-2	29.2	1.5	19.5	Bundle	Anthophyllite
-3	10.0	0.5	20	Bundle	Anthophyllite
-4	22.5	1.3	17.3	Bundle	Anthophyllite
-5	11.7	1.0	11.7	Bundle	Anthophyllite
-6	9.5	1.0	N/A	Bundle	Talc
-7	31.0	1.0	31	Bundle	Anthophyllite
-8	9.0	0.25	36	Fiber	Anthophyllite
-9	3.8	0.3	12.7	Bundle	Anthophyllite

Average Aspect Ratio: 22.4

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65D

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	18.0	1.5	12	Bundle	Anthophyllite
-2	14.3	1.5	9.5	Bundle	Anthophyllite
-3	20.2	1.3	15.5	Bundle	Anthophyllite
-4	11.2	0.7	16	Bundle	Anthophyllite
-5	6.8	0.7	9.7	Bundle	Anthophyllite
-6	13.3	0.7	19	Bundle	Anthophyllite
-7	22.3	1.5	14.9	Bundle	Anthophyllite
-8	17.0	0.22	77.3	Fiber	Anthophyllite
-9	28.0	2.5	11.2	Bundle	Anthophyllite
-10	9.5	1.3	7.3	Bundle	Anthophyllite
-11	12.0	0.8	15	Bundle	Anthophyllite
-12	10.2	0.4	25.5	Bundle	Anthophyllite
-13	23.0	3.5	6.6	Bundle	Anthophyllite

Average Aspect Ratio: 18.4

37D

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	15.8	2.6	6.1	Bundle	Anthophyllite

Average Aspect Ratio: 6.1

45D

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	17.5	2.2	8.0	Bundle	Anthophyllite

Average Aspect Ratio: 8.0

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M68503-001

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	9.89	0.46	21.5	Bundle	Anthophyllite
-2	3.2	0.59	5.4	Bundle	Tremolite
-3	10.4	1.38	7.5	Bundle	Tremolite

Average Aspect Ratio: 11.5

M69042-010

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	9.2	1.5	6.1	Bundle	Anthophyllite
-2	8.9	0.42	21.2	Bundle	Anthophyllite

Average Aspect Ratio: 11.5

31F

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	21.6	1.3	16.6	Bundle	Anthophyllite

Average Aspect Ratio: 16.6

31G

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	30.1	0.7	43	Bundle	Anthophyllite
-2	13.5	0.7	19.3	Bundle	Anthophyllite
-3	7.0	0.7	10	Bundle	Anthophyllite
-4	22.5	1.5	15	Bundle	Anthophyllite

Average Aspect Ratio: 21.8

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Table 5
Summary of Results for Johnson & Johnson's
1990's Historical JBP & Imerys Samples

MAS/J ³ Sample Number	Client Sample ID	Year of Mnfr.	Amphibole Asbestos Structures/g	Amphibole Asbestos wt. %	Analytical Sensitivity Structures/g	ISO PLM wt. %	Blount PLM wt. %
M69757-005	20180343-03A Imerys	1990	27000	0.000010	4500	<0.1 Tre/Act <0.1 Anth	<0.1 Tre/Act <0.1 Anth
M69757-007	20180358-01A Imerys	1990	39000	0.00030	4300	<0.1 Tre/Act	<0.1 Tre/Act <0.1 Anth
M69751-039	20180320-01A Imerys	1991	<4400	<0.0000268	4400	NAD	NAD
M69751-040	20180320-13A Imerys	1991	13000	0.000015	4500	NAD	<0.1 Tre/Act
M68503-016 JBP	2018-0060-33 JBP 001	1994	<9000	<0.0000268	9000	NAD	NAD
M69757-004	20180339-05A Imerys	1994	<4400	<0.0000268	<4400	NAD	NAD
M69751-036	20180313-02A Imerys	1995	4400	0.00000022	4400	NAD	NAD
M68503-017 JBP	2018-0060-38 JBP 006	1996	<9000	<0.0000268	9000	NAD	NAD
M69757-006	20180344-04A Imerys	1996	<4400	<0.0000268	4400	NAD	NAD
M69751-002	20180315-021A Imerys	1999	<4400	<0.0000268	4400	NAD	NAD

NAD: no asbestos detected.

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**M69757-005**

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	2.32	0.21	11.0	Bundle	Anthophyllite
-2	6.1	0.42	14.5	Bundle	Anthophyllite
-3	4.4	0.84	5.2	Bundle	Anthophyllite
-4	2.72	0.42	6.5	Bundle	Anthophyllite
-5	8.7	0.38	22.9	Bundle	Anthophyllite
-6	4.82	0.76	6.3	Bundle	Anthophyllite

Average Aspect Ratio: 11.1

M69757-007

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	5.6	1.1	5.1	Bundle	Anthophyllite
-2	4.6	0.64	7.2	Bundle	Anthophyllite
-3	9.9	0.36	27.5	Fiber	Anthophyllite
-4	10.9	0.35	31.1	Bundle	Anthophyllite
-5	11.7	1.4	8.4	Bundle	Anthophyllite
-6	11.6	1.1	10.5	Bundle	Actinolite
-7	11.8	1.6	7.4	Bundle	Anthophyllite
-8	8	1.3	6.2	Bundle	Anthophyllite
-9	49.4	2.1	23.5	Bundle	Talc-Anth

Average Aspect Ratio: 11.1

M69751-040

Str. #	Length (μm)	Width (μm)	Aspect Ratio	Structure Type	Asbestos Type
-1	7.4	0.62	11.9	Bundle	Anthophyllite
-2	14.9	0.74	20.1	Bundle	Anthophyllite
-3	6.72	0.62	10.8	Bundle	Anthophyllite

Average Aspect Ratio: 11.1

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**M69751-036**

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	6.3	0.18	35.0	Bundle	Tremolite

Average Aspect Ratio: 35.0

Table 6
Summary of Results for Johnson & Johnson's
2000's Historical Imerys Samples

MAS/J ³ Sample Number	Client Sample ID	Year of Mnfr.	Amphibol e Asbestos Structures /g	Amphibole Asbestos wt. %	Analytical Sensitivity Structures/g	ISO PLM wt. %	Blount PLM wt. %
M69751-001	2018-0315-01A	2001-2002	4400	0.000017	4400	NAD	NAD
M69751-006	2018-0316-020A	2000	4600	0.0000024	4600	NAD	<0.1 Tre/Act
M69751-007	2018-0316-021A	2000	8700	0.000024	4300	NAD	NAD
M69751-038	2018-0317-04A	2000	<4400	<0.0000268	4400	NAD	NAD
M69751-004	2018-0315-040A	2001	<4300	<0.0000268	4300	NAD	NAD
M69751-008	2018-0316-022A	2003	<4400	<0.0000268	4400	NAD	NAD

NAD: no asbestos detected.

M69751-001

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	10.5	1.2	8.8	Bundle	Tremolite

Average Aspect Ratio: 8.8

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M69751-006

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	8.2	0.5	16.4	Bundle	Tremolite

Average Aspect Ratio: 35.0

M69751-007

Str. #	Length (µm)	Width (µm)	Aspect Ratio	Structure Type	Asbestos Type
-1	16.0	1	16.0	Bundle	Tremolite
-2	7.6	0.9	8.4	Bundle	Tremolite

Average Aspect Ratio: 12.2

Table 7
Summary of J³ XRD & PLM Analysis
Asian

MAS Sample Number	Date of Manuf.	ISO XRD
M69248-001	N/A	NAD
M69248-002	1979	inconclusive
M69248-003	1980-1984	positive
M69248-004	N/A	NAD
M69248-005	N/A	NAD
M69248-006	1982	NAD
M69248-007	N/A	positive

NAD: no asbestos detected N/A: dates of manufacture not provided by J&J

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Table 8
Summary of J³ XRD & PLM Analysis
1960's

MAS Sample Number	Date of Manuf.	ISO XRD	J ³ ISO PLM %	MAS ISO PLM %
M68503-010	1960	NAD	NAD	NAD
M68503-009	1962	NAD	NAD	NAD
M68508-024	1963	NAD	NAD	NAD
M68503-004	1964	NAD	NAD	<0.1 Trem/Act
M68503-014	1965	NAD	NAD	NAD
M68503-011	1966	NAD	NAD	NAD
M68503-027	1966	NAD	NAD	NAD
M69042-007	1966-1967	NAD	---	NAD
M69042-003	1967	NAD	---	NAD
M69042-005	1967	NAD	---	NAD
M69042-006	1967	NAD	---	NAD
M68503-019	1967	NAD	NAD	NAD
M68503-038	1968	NAD	NAD	NAD
M68503-026	1969	NAD	NAD	<0.1 Trem/Act

NAD: no asbestos detected

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Summary of J³ XRD & J³/ MAS PLM Analysis

1970's

MAS Sample Number	Date of Manuf.	ISO XRD	J3 ISO PLM %	MAS ISO PLM %
M68503-005	1970	NAD	NAD	NAD
M69042-009	1970	NAD	---*	<0.1 Trem/Act
M68503-029	1971	NAD	NAD	NAD
M68503-021	1972	NAD	NAD	NAD
M68503-023	1973	NAD	NAD	<0.1 Anth.
M68503-028	1974	NAD	NAD	NAD
02D	1975	NAD	NAD	---
M69042-001	1975	NAD	---	<0.1 Trem/Act <0.1 Anth
M68503-046	1975	NAD	NAD	NAD
M68503-042	1976	NAD	NAD	<0.1 Trem/Act <0.1 Anth
M68233-001	1978	NAD	---	<0.1 Trem/Act
M68233-002	1978	NAD	---	<0.1 Trem/Act
M68503-057	1978	NAD	NAD	<0.1 Trem/Act <0.1 Anth
M68503-020	1978	NAD	NAD	<0.1 Anth
M69042-002	1978	NAD	---	<0.1 Trem/Act <0.1 Anth
M69042-004	1978	NAD	---	<0.1 Trem/Act <0.1 Anth
M69042-008	1978	NAD	---	<0.1 Anth
07D	1978	NAD	NAD	--
15D	1978	NAD	NAD	--
50D	1978	NAD	NAD	--
M68503-059	1979	NAD	NAD	<0.1 Trem/Act <0.1 Anth

NAD: no asbestos detected *: not analyzed

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Summary of J³ XRD & PLM Analysis

1980's

MAS/P ³ Sample Number	Date of Manuf.	ISO XRD	J3 ISO PLM	MAS ISO PLM
10D	1980	NAD	NAD	--*
38D	1980	NAD	NAD	--
63D	1980-1981	NAD	NAD	--
52D	1981	NAD	NAD	--
65D	1981	NAD	NAD	--
37D	1982	NAD	NAD	--
45D	1982	NAD	NAD	--
51D	1982	NAD	NAD	--
66D	1982	NAD	NAD	--
21D	1983	NAD	NAD	--
M68503-001	1984	NAD	NAD	<0.1% Trem/Act
M69042-010	1985	NAD	---	<0.1% Trem/Act
31F	1986	NAD	NAD	--
31G	1986	NAD	NAD	--

NAD: no asbestos detected, *: not analyzed

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Summary of J³ XRD Analysis

1990's

MAS Sample Number	Date of Manuf.	ISO XRD
M69757-005	1990	N/A
M69757-007	1990	N/A
M69751-039	1991	N/A
M69751-040	1991	N/A
M68503-016	1994	NAD
M69757-004	1994	N/A
M69751-036	1995	N/A
M68503-017	1996	NAD
M69757-006	1996	N/A
M69751-002	1999	N/A

NAD: no asbestos detected N/A: Sample not analyzed

Summary of J³ XRD Analysis

Early 2000's

MAS Sample Number	Date of Manuf.	ISO XRD
M69751-005	2000	N/A
M69751-007	2000	N/A
M69751-039	2000	N/A
M69751-040	2000	N/A
M69751-004	2001	N/A
M69751-036	2001	N/A

N/A: not analyzed

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Table 9

Occurrence of Fibrous Talc in Historical J&J Cosmetic Talcum Powders

1960's

Sample #	Date of Manufacture	TEM Analysis F.T	Talc Fibers per gram	ISO22262-1 PLM Analysis
M68503-010	1960	Trace	852,000	Trace
M68503-009	1962	Trace	882,000	Trace
M68503-024	1963	Trace	896,000	Trace
M68503-004	1964	Trace	298,000	Trace
M68503-014	1965	Trace	864,000	Trace
M68503-027	1966	Trace	290,000	Trace
M68503-011	1967	NSD	N/A	Trace
M68503-019	1967	Trace	892,000	Trace
M69042-003	1967	Trace	890,000	Moderate
M69042-005	1967	Trace	873,000	Moderate
M69042-006	1967	NSD	N/A	Moderate
M69042-007	1967	NSD	N/A	Moderate
M68503-038	1968	Trace	304,000	Trace
M68503-026	1969	Trace	864,000	Trace

N/A: Not applicable, fibrous talc calculations not possible

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1970's

Sample #	Date of Manufacture	TEM Analysis F.T	Talc Fibers per gram	ISO22262-1 PLM Analysis
M68503-005	1970	Trace	877,000	Trace
M69042-009	1970	Trace	637,000	Moderate
M68503-029	1971	Trace	1,020,000	Trace
M68503-021	1972	NSD	N/A	Trace
M68503-023	1973	Trace	876,000	Trace
M68503-028	1974	NSD	N/A	Trace
02D	1975	1 Fiber*	N/A	N/A
M69042-001	1975	NSD	N/A	N/A
M68503-046	1975	NSD	N/A	Trace
M68503-042	1976	NSD	N/A	Trace
M68233-001	1978	NSD	N/A	Trace
M68233-002	1978	Trace	735,00	Trace
M68503-057	1977	NSD	N/A	Trace
M68503-020	1978	Trace	868,000	Trace
M69042-002	1978	Trace	890,000	Moderate
M69042-004	1978	Trace	603,000	Moderate
M69042-008	1978	NSD	N/A	Moderate
07D	1978	1 Fiber	N/A	NSD
15D	1978	None reported	N/A	NSD
50D	1978	3 Fibers	N/A	NSD
M68503-059	1979	Trace	855,000	Trace

*No criteria provide by P³ for fibrous talc estimation. N/A: Not applicable, fibrous talc calculations not possible

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1980's

Sample #	Date of Manufacture	TEM Analysis F.T	Talc Fibers per gram	ISO22262-1 PLM Analysis
38D	1980	None Reported	N/A	N/A
52D	1981	None Reported	N/A	N/A
65D	1981	None Reported	N/A	N/A
37D	1982	2 Fibers*	N/A	N/A
45D	1982	3 Fibers	N/A	N/A
51D	1982	None Reported	N/A	N/A
66D	1982	None Reported	N/A	N/A
21D	1983	1 Fiber	N/A	N/A
M68503-001	1984	Trace	624,000	Trace
M69042-010	1985	Trace	624,000	Moderate
31F	1986	1 Fiber	N/A	N/A
31G	1986	2 Fibers	N/A	N/A
M69751-037	1989	Trace	548,000	Moderate

*No criteria provide by P³ for fibrous talc estimation. N/A: Not applicable, fibrous talc calculations not possible

1990's

Sample #	Date of Manufacture	TEM Analysis F.T	Talc Fibers Per gram	ISO22262-1 PLM Analysis
M69757-005	1990	Trace	434,000	Moderate
M69757-007	1990	Trace	478,000	Moderate
M69751-039	1991	Trace	497,000	Moderate
M69751-040	1991	Trace	451,000	Moderate
M68503-016	1994	Trace	898,000	Trace
M69757-004	1994	Trace	403,000	Trace
M69751-036	1995	Trace	438,000	Moderate
M68503-017	1996	Trace	895,000	Trace
M69757-006	1996	Trace	439,000	Moderate
M69751-002	1999	NSD	N/A	Moderate

N/A: Not applicable, fibrous talc calculations not possible

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Early 2000's

Sample #	Date of Manufacture	TEM Analysis F.T	Talc Fibers Per gram	ISO22262-1 PLM Analysis
M69751-001	2000	Trace	471,000	Moderate
M69751-006	2000	Trace	439,000	Trace
M69751-007	2000	Trace	458,000	Trace
M69571-038	2000	Trace	437,000	Moderate
M69751-004	2001	Trace	434,000	Moderate
M69751-008	2003	NSD	N/A	Trace

N/A: Not applicable, fibrous talc calculations not possible

Asian

Sample #	Date of Manufacture	TEM Analysis F.T	Talc Fibers per gram	ISO22262-1 PLM Analysis
M69248-001	Unknown*	Trace	577,000	Trace
M69248-002	1979	Trace	582,000	Trace
M69248-003	1980-1984	Trace	930,000	Trace
M69248-004	unknown	Trace	860,000	Trace
M69248-005	unknown	Trace	870,000	Trace
M69248-006	1982	NSD	N/A	Trace
M69248-007	unknown	NSD	N/A	Trace

*J&J did not provide date of manufacture. N/A: Not applicable, fibrous talc calculations not possible

Exhibit 91

Melinda Darby Dyar, Ph.D.

Page 1

UNITED STATES DISTRICT COURT
DISTRICT OF NEW JERSEY

IN RE: JOHNSON &)
JOHNSON TALCUM POWDER)
PRODUCTS MARKETING)
SALES PRACTICES AND) MDL 16-2738
PRODUCT LIABILITY) (FLW)(LHG)
LITIGATION)
_____)
THIS DOCUMENT)
PERTAINS TO ALL CASES)

TUESDAY, APRIL 2, 2019

- - -

Videotaped deposition of Melinda Darby
Dyar, Ph.D., held at the offices of SKADDEN,
ARPS, MEAGHER & FLOM, LLP, Four Times Square,
New York, New York, commencing at 9:03 a.m.,
on the above date, before Carrie A. Campbell,
Registered Diplomate Reporter and Certified
Realtime Reporter.

- - -

GOLKOW LITIGATION SERVICES
877.370.3377 ph | 917.591.5672 fax
deps@golkow.com

Melinda Darby Dyar, Ph.D.

Page 2	Page 4
<p>1 APPEARANCES:</p> <p>2</p> <p>3 BEASLEY ALLEN LAW FIRM</p> <p>4 BY: LEIGH O'DELL</p> <p>5 leigh.odell@BeasleyAllen.com</p> <p>6 218 Commerce Street</p> <p>7 Montgomery, Alabama 36104</p> <p>8 (334) 269-2343</p> <p>9</p> <p>10 MOTLEY RICE LLC</p> <p>11 BY: NATHAN D. FINCH</p> <p>12 nfinch@motleyrice.com</p> <p>13 401 9th Street NW, Suite 1001</p> <p>14 Washington, DC 20004</p> <p>15 (202) 232-5507</p> <p>16</p> <p>17 COHEN PLACITELLA ROTH PC</p> <p>18 BY: DENNIS M. GEIER</p> <p>19 dgeier@cpirlaw.com</p> <p>20 127 Maple Avenue</p> <p>21 Red Bank, New Jersey 07701</p> <p>22 (732) 747-9003</p> <p>23 Counsel for Plaintiffs</p> <p>24</p> <p>25</p> <p>16 ORRICK, HERRINGTON & SUTCLIFFE LLP</p> <p>17 BY: ALEX V. CHACHKES</p> <p>18 achachkes@orrick.com</p> <p>19 51 West 52nd Street</p> <p>20 New York, New York 10019</p> <p>21 (212) 506-3742</p> <p>22</p> <p>23 DRINKER BIDDLE & REATH LLP</p> <p>24 BY: SUSAN M. SHARKO</p> <p>25 Susan.Sharko@dbr.com</p> <p>26 JACK N. FROST, JR.</p> <p>27 jack.frost@dbr.com</p> <p>28 600 Campus Drive</p> <p>29 Florham Park, New Jersey 07932-1047</p> <p>30 (973) 549-7000</p> <p>31 Counsel for Defendant Johnson &</p> <p>32 Johnson</p>	<p>1 INDEX</p> <p>2 PAGE</p> <p>3 APPEARANCES..... 2</p> <p>4 EXAMINATIONS</p> <p>5 BY MR. FINCH..... 9</p> <p>6 BY MR. CHACHKES..... 357</p> <p>7 BY MR. FINCH..... 363</p> <p>8</p> <p>9 EXHIBITS</p> <p>10 No. Description Page</p> <p>11 Dyar Notice of Oral and Videotaped 14</p> <p>12 Exhibit 1 Deposition of M. Darby Dyar,</p> <p>13 PhD, and Duces Tecum</p> <p>14 Dyar Expert Report of M. Darby 22</p> <p>15 Exhibit 2 Dyar, PhD, for General</p> <p>16 Causation Daubert Hearing</p> <p>17 Dyar Electronic Document Production 25</p> <p>18 Exhibit 3</p> <p>19</p> <p>20 Dyar ISO 22262-1, Air quality - 60</p> <p>21 Exhibit 4 Bulk materials</p> <p>22 Dyar ISO 22262-2, Air quality - 60</p> <p>23 Exhibit 5 Bulk materials</p> <p>24</p> <p>25 Dyar ISO 13794, Ambient air - 60</p> <p>26 Exhibit 6 Determination of asbestos</p> <p>27 fibres - Indirect-transfer</p> <p>28 transmission electron</p> <p>29 microscopy method</p> <p>30</p> <p>31 Dyar Methodology for the 60</p> <p>32 Exhibit 7 Measurement of Airborne</p> <p>33 Asbestos by Electron</p> <p>34 Microscopy, George Yamate, et</p> <p>35 al.</p>
Page 3	Page 5
<p>1 SEYFARTH SHAW LLP</p> <p>2 BY: THOMAS T. LOCKE</p> <p>3 tlocke@seyfarth.com</p> <p>4 975 F Street, N.W.</p> <p>5 Washington, DC 20004</p> <p>6 (202) 463-2400</p> <p>7 Counsel for Defendant Personal Care</p> <p>8 Products Council</p> <p>9</p> <p>10 TUCKER ELLIS LLP</p> <p>11 BY: SANDRA WUNDERLICH</p> <p>12 sandra.wunderlich@tuckerellis.com</p> <p>13 100 South Fourth Street, Suite 600</p> <p>14 St. Louis, Missouri 63102</p> <p>15 (314) 571-4965</p> <p>16 Counsel for PTI Union, LLC and PTI</p> <p>17 Royston, LLC</p> <p>18</p> <p>19 ALSO PRESENT:</p> <p>20 LIZZY HARRISON, Motley Rice</p> <p>21</p> <p>22 VIDEOGRAPHER:</p> <p>23 HENRY MARTE,</p> <p>24 Golkow Litigation Services</p> <p>25 ---</p>	<p>1 Dyar The Analysis of Johnson & 88</p> <p>2 Exhibit 8 Johnson's Historical Product</p> <p>3 Containers and Imerys'</p> <p>4 Historical Railroad Car</p> <p>5 Samples from the 1960s to the</p> <p>6 Early 2000s for Amphibole</p> <p>7 Asbestos, Second Supplemental</p> <p>8 Report, Longo and Rigler</p> <p>9</p> <p>10 Dyar Manual of Mineralogy, Klein 92</p> <p>11 Exhibit 9 and Hurlbut</p> <p>12 Dyar Amphibole Content of Cosmetic 100</p> <p>13 Exhibit 10 and Pharmaceutical Tales, AM</p> <p>14 Blount</p> <p>15 Dyar Defining Asbestos: 139</p> <p>16 Exhibit 11 Differences between the Built</p> <p>17 and Natural Environments,</p> <p>18 Gunther</p> <p>19</p> <p>20 Dyar ResearchGate printout of 143</p> <p>21 Exhibit 12 Tremolite and Mesothelioma</p> <p>22 Dyar Mineralogy and Optical 147</p> <p>23 Exhibit 13 Mineralogy, Dyar, et al.</p> <p>24</p> <p>25 Dyar Page 182 from "Chemical 148</p> <p>26 Exhibit 14 Analysis of Minerals"</p> <p>27 Dyar Case report of 152</p> <p>28 Exhibit 15 Erionite-Associated Malignant</p> <p>29 Pleural Mesothelioma in</p> <p>30 Mexico, Oczypok, et al.</p> <p>31</p> <p>32 Dyar Interoffice Correspondence, 172</p> <p>33 Exhibit 16 March 25, 1992,</p> <p>34 IMERYS 219720 - IMERYS 219722</p> <p>35</p> <p>36 Dyar May 23, 2002 Technical Report 172</p> <p>37 Exhibit 17 of Julie Pier,</p> <p>38 IMERYS 422289 - IMERYS 422290</p> <p>39</p> <p>40 Dyar Walter McCrone Associates, 223</p> <p>41 Exhibit 18 Inc., November 5, 1975,</p> <p>42 JN1L61_000079334 -</p> <p>43 JN1L61_000079335</p> <p>44</p> <p>45</p>

Melinda Darby Dyar, Ph.D.

Page 6	Page 8
<p>1 Dyar Walter McCrone Associates 1 223 Exhibit 19 July 1975 letter, 2 JNJMX68_000012745 - JNJMX68_000012749 3 4 Dyar May 24, 1975 Walter McCrone 223 Exhibit 20 letter from RN Miller, JNJTACL000387254 5 6 Dyar Diffraction Verifications, 236 Exhibit 21 M68233-001, M68233-002 7 Dyar MAS, LLC PLM Analysis, 279 Exhibit 22 M69680-015BL 8 9 Dyar The Asbestiform and 329 Exhibit 23 Nonasbestiform Mineral Growth Habit and Their Relationship 10 to Cancer Studies, A Pictorial Presentation, April 2003 11 12 Dyar Mineral Commodity Profiles - 333 Exhibit 24 Asbestos, USGS 13 Dyar Asbestos, A Mineral of 343 Exhibit 25 Unparalleled Properties, 14 Badollet 15 Dyar J&J Consumer Companies 350 Exhibit 26 Worldwide Specification, 16 TM7024, JNJNL61_000005032 - 17 JNJNL61_000005040 18 19 (Exhibits attached to the deposition.) 20 21 22 23 24 25</p>	<p>1 now on the record. My name is Henry 2 Marte. I'm a videographer with Golkow 3 Litigation Services. 4 Today's date is April 2, 2019, 5 and the time is 9:03 a.m. 6 This videotaped deposition is 7 being held at 4 Times Square, 8 New York, New York, in the Matter of 9 Talcum Powder Litigation. 10 The deponent today is 11 Dr. Melinda Darby Dyar. 12 Will all appearances please 13 introduce themselves for the record. 14 MR. FINCH: Yes. Nate Finch 15 for various ovarian cancer victim 16 plaintiffs. 17 MR. GEIER: Dennis Geier for 18 the plaintiffs. 19 MS. HARRISON: Lizzy Harrison, 20 Motley Rice. 21 MS. O'DELL: Leigh O'Dell on 22 behalf of the plaintiff steering 23 committee. 24 MR. LOCKE: Sorry. 25 MR. CHACHKES: Yeah. Alex</p>
Page 7	Page 9
<p>1 MS. O'DELL: I just have an 2 objection before the deposition 3 starts. 4 Yesterday at 5:50 we received a 5 production of new materials, 6 approximately 140 pages of new data 7 that we had not been provided 8 previously. We've not had an 9 opportunity to review and analyze that 10 data, and based on the late 11 production, we will move to keep this 12 deposition open and continue it after 13 we've had an opportunity to do so. 14 MR. CHACHKES: And obviously we 15 disagree. And you'll have the 16 opportunity to ask the witness about 17 those documents, and you'll find 18 there's no reason to keep anything 19 open. 20 MS. O'DELL: We'll see. 21 MR. FINCH: We'll see. 22 MS. O'DELL: We'll reserve the 23 right to take that to Judge Pisano if 24 we can't reach an agreement. 25 VIDEOGRAPHER: Okay. We are</p>	<p>1 Chachkes on behalf of J&J, Orrick 2 Herrington. 3 MR. FROST: Jack Frost, Drinker 4 Biddle and Reath, on behalf of Johnson 5 & Johnson. 6 MS. SHARKO: Susan Sharko, 7 Drinker Biddle, same. 8 MS. WUNDERLICH: Sandra 9 Wunderlich, Tucker Ellis, on behalf of 10 PTI Royston and PTI Union. 11 MR. LOCKE: Tom Locke for the 12 Personal Care Products Council. 13 VIDEOGRAPHER: Okay. Will the 14 court reporter please administer the 15 oath to the witness. 16 17 MELINDA DARBY DYAR, Ph.D., 18 of lawful age, having been first duly sworn 19 to tell the truth, the whole truth and 20 nothing but the truth, deposes and says on 21 behalf of the Plaintiffs, as follows: 22 23 DIRECT EXAMINATION 24 QUESTIONS BY MR. FINCH: 25 Q. Good morning, Ms. Darby Dyar.</p>

3 (Pages 6 to 9)

Melinda Darby Dyar, Ph.D.

Page 10	Page 12
<p>1 My name is Nate Finch. I 2 introduced myself off the record to you. As 3 I said before, I represent various ovarian 4 cancer victim plaintiffs. 5 Have you ever had your 6 deposition taken before? 7 A. No. 8 Q. Have you ever testified in a 9 courtroom before? 10 A. No. 11 Q. Have you ever done what's 12 called a mock deposition, where someone 13 videotapes you and asks you questions as if 14 you were being deposed or testifying in 15 court? 16 MR. CHACHKES: So I'm going to 17 object on work product grounds. 18 You can answer to the extent 19 it's not anything you've done with 20 counsel in this case. 21 THE WITNESS: Correct, it's not 22 anything I've ever done with counsel 23 in this case. 24 QUESTIONS BY MR. FINCH: 25 Q. So never done it your entire</p>	<p>1 income into. 2 Q. How long has Palouse Minerals 3 been in existence? 4 A. A couple months. 5 Q. In what state was it formed? 6 What's the -- 7 A. Massachusetts. 8 Q. So it's a Massachusetts LLC? 9 A. Yes. 10 Q. And what's the business address 11 for it? 12 A. 161 Chestnut Street in Amherst, 13 Mass. 14 Q. Is that the same as your office 15 address? 16 A. Yes, it is. 17 Q. Is it -- 18 A. To which office are you 19 referring? 20 Q. Or which office does it 21 correspond to? 22 A. It corresponds to my home 23 office. 24 Q. So it's your home address as 25 well?</p>
Page 11	Page 13
<p>1 life, or you've done it in this case? 2 MR. CHACHKES: So the objection 3 was don't talk about what we did in 4 this case, but you're welcome to talk 5 about other stuff. 6 THE WITNESS: No, I've never 7 done it ever before. 8 QUESTIONS BY MR. FINCH: 9 Q. So am I correct that you have 10 never been recognized by a court as an expert 11 in anything? Is that correct? 12 A. That is correct. 13 Q. What is Palouse Minerals, LLC? 14 A. It is an LLC entity that I 15 created for the purposes of -- on the basis 16 of the recommendation of my personal lawyer. 17 Q. Created for the purposes of 18 what, receiving funds that you earn as an 19 expert witness? 20 Is that one of the reasons you 21 created it? 22 A. I do considerable consulting 23 for NASA, and I decided it would be useful to 24 have an entity that I could consolidate my 25 non-Mount Holyoke and non-planetary science</p>	<p>1 A. Correct. 2 Q. Are you the -- the sole member 3 of Palouse Minerals, LLC, meaning the sole 4 person that has an ownership stake in it? 5 A. Yes. 6 Q. There are no other -- are there 7 any other limited partners that receive an 8 income distribution or other distribution for 9 Palouse Minerals? 10 A. No. 11 Q. Does it have any employees? 12 A. Other than me, no. 13 Q. When were you first contacted 14 by someone -- let me back up. 15 Who are you working for in 16 connection with this case in which your 17 deposition is being taken today? 18 A. I'm not exactly sure what you 19 mean. 20 Do you mean who do I send the 21 bills to? 22 Q. Well, you're being compensated 23 for your time, I assume, correct? 24 A. Correct. 25 Q. All right. And you send the</p>

4 (Pages 10 to 13)

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 14</p> <p>1 bills to Tucker Ellis. That's a law firm; is 2 that correct? 3 A. I believe so. 4 Q. And do you have an 5 understanding as to what party in this 6 litigation you are serving as an expert 7 witness for? 8 A. Yes. 9 Q. All right. Who are you working 10 for? 11 A. So the checks come from Orrick, 12 and Orrick is hired by Johnson & Johnson. 13 Q. Are you working for any other 14 party to this litigation, other than 15 Johnson & Johnson or Johnson & Johnson 16 Consumer, Inc., or any other Johnson & 17 Johnson subsidiary? 18 A. No. 19 Q. So you're not being compensated 20 or doing any work with a company called 21 Imerys, for example? 22 A. No. 23 MR. FINCH: Lizzy, can I have 24 the notice of deposition? 25 (Dyar Exhibit 1 marked for</p>	<p style="text-align: right;">Page 16</p> <p>1 this expert engagement other than you? 2 A. No. 3 Q. The reason I ask that question, 4 on the invoices that were produced yesterday 5 evening, there are a couple of instances 6 where there's redactions and the person 7 was -- the person or entity was redacted, and 8 that led me to believe there might have been 9 someone else other than you who worked on the 10 report. 11 MR. CHACHKES: Objection. 12 THE WITNESS: No one else but 13 me worked on the report. 14 QUESTIONS BY MR. FINCH: 15 Q. Okay. What were you asked to 16 do by Johnson & Johnson or its lawyers? 17 A. I was asked to review the 18 methodology used by Drs. Longo and Rigler in 19 a series of reports. 20 Q. Anything else? 21 A. I was asked to write a report 22 giving my review. 23 Q. What methodology did you follow 24 in analyzing Dr. Longo and Rigler's reports? 25 A. Well, I've been a reviewer of</p>
<p style="text-align: right;">Page 15</p> <p>1 identification.) 2 QUESTIONS BY MR. FINCH: 3 Q. Ma'am, I've put what's been 4 marked as Darby Dyar Exhibit 1 in front of 5 you. 6 Have you ever seen this or 7 discussed it, the subject matters of what it 8 is, with anyone? 9 A. Yes and yes. 10 Q. And what is your understanding 11 of what this is? 12 A. It's a notice that I'm going to 13 testify today, and these are the documents 14 that are related to the case. 15 Q. Okay. When were you first 16 contacted by someone on behalf of Johnson & 17 Johnson to do work for it in connection with 18 these cases? 19 A. I don't remember exactly, but 20 sometime last fall after school started. 21 Q. Okay. And am I correct that 22 your time is billed out at \$500 an hour? 23 A. That is correct. 24 Q. And has anyone else from 25 Palouse Minerals done work in connection with</p>	<p style="text-align: right;">Page 17</p> <p>1 scientific documents for almost 40 years, and 2 so I used the same methodology I'd use for 3 reviewing a scientific paper or a proposal or 4 any kind of report that comes across my 5 research interests. 6 So I first read the report 7 carefully, every word. Then I looked at all 8 of the math and all the numbers and analyzed 9 the numbers. Then I sought out all of the 10 references that were cited in those reports 11 and tried to read all of them. And then I 12 looked at the report many times and tried to 13 see if the information in the report 14 justified the conclusions. 15 Q. Did you test any talc that was 16 the source of Johnson's baby powder or SHOWER 17 TO SHOWER® yourself? 18 A. No. 19 Q. Did you test any talc that was 20 mined either in Italy or Vermont or China for 21 the purposes of analyzing whether or not it 22 contained asbestos or asbestos fibers? 23 A. No. 24 Q. Did you review any internal 25 documents of Johnson & Johnson that indicated</p>

5 (Pages 14 to 17)

Melinda Darby Dyar, Ph.D.

Page 18	Page 20
<p>1 the results of its testing of either its baby 2 powder or SHOWER TO SHOWER® products or the 3 ore from the Vermont mine or other sources of 4 talc? 5 A. No. 6 Q. Did you review any testimony 7 from any of Johnson & Johnson's corporate 8 witnesses related to the source of -- let me 9 just ask it this way. 10 Did you review any testimony of 11 anyone other than Dr. Longo and Dr. Rigler? 12 A. Yes, I reviewed reports only by 13 Krekeler, Cook and Campion. 14 Q. And you reviewed their reports, 15 but you haven't commented on any of those 16 reports; is that correct? 17 A. There was no need to comment on 18 those reports because they did not have -- 19 they did not bear on my evaluation of the 20 methodology of Longo and Rigler. 21 Q. Okay. 22 A. But I read them just in case. 23 Q. All right. Am I correct that 24 you don't have an opinion one way or another 25 as to whether or not there is asbestos in</p>	<p>1 A. My name appears on publications 2 in which the author list includes Matt, yes. 3 Q. Have you reviewed any of 4 Mr. Sanchez's testimony in connection with 5 any Johnson & Johnson talc litigation? 6 A. No. 7 Q. You have published multiple 8 papers and also a book with a gentleman by 9 the name of Mickey Gunther, correct? 10 A. That's correct. 11 Q. Have you ever reviewed any of 12 Dr. Gunther's testimony in asbestos 13 litigation on behalf of any of the parties 14 that he's worked for? 15 A. No. 16 Q. Did you review any deposition 17 or trial testimony of any Johnson & Johnson 18 witness in connection with your work in this 19 case? 20 And by that I would include 21 Dr. John Hopkins or any of the other 22 employees or former employees of Johnson & 23 Johnson. 24 A. No. 25 Q. Did you review any summaries of</p>
Page 19	Page 21
<p>1 Vermont talc that was a source for Johnson's 2 baby powder? 3 A. Can you restate that question? 4 Q. I didn't see anywhere in your 5 report an affirmative opinion as to whether 6 or not there is or is not asbestiform 7 materials, asbestos fibers, in the talc from 8 either Vermont or Italy or China that was the 9 source of Johnson's baby powder. 10 MR. LOCKE: Objection. 11 THE WITNESS: No, my job in 12 this matter was to review the 13 methodology of Drs. Longo and Rigler. 14 QUESTIONS BY MR. FINCH: 15 Q. Did you review the testimony 16 of -- do you know Ann Wylie, by any chance? 17 A. I believe I've met Ann Wylie 18 once, maybe, but I couldn't pick her out of a 19 crowd. 20 Q. Did you review her testimony 21 that was taken in connection with these cases 22 as part of your work here? 23 A. No. 24 Q. You have written papers with 25 Matthew Sanchez, correct?</p>	<p>1 any deposition or trial testimony of anyone 2 other than possibly Dr. Longo and Dr. Rigler? 3 A. No. 4 Q. When you were first contacted 5 to work on behalf of Johnson & Johnson, who 6 did you -- how did -- how were you first 7 contacted? 8 Who contacted you? 9 A. I -- to the best of my memory, 10 I was sitting in my Mount Holyoke office, and 11 I got a phone call from a lawyer in 12 Cleveland. 13 Q. This was a lawyer for the 14 Tucker Ellis firm? 15 A. I'm not sure where he works. 16 Q. What was the name of the 17 lawyer? 18 A. Chris Caryl, Caryl. I'm not 19 sure how you pronounce his name. 20 Q. And in that conversation, what 21 did he ask you to do? 22 A. He asked me if I had ever done 23 any expert witness work and if that would 24 interest me, and he told me a little bit 25 about the case. I don't remember exactly</p>

6 (Pages 18 to 21)

Melinda Darby Dyar, Ph.D.

Page 22	Page 24
<p>1 what he said, but he asked me if I'd be 2 interested, and I said I would think about 3 it. 4 Q. And obviously you eventually 5 said yes, correct? 6 A. Correct. 7 Q. And you ultimately put together 8 an expert witness report that contains your 9 opinions and conclusions in this case; is 10 that correct? 11 A. Yes. 12 MR. FINCH: Lizzy, can I have 13 the report? 14 (Dyar Exhibit 2 marked for 15 identification.) 16 QUESTIONS BY MR. FINCH: 17 Q. Ma'am, I've marked as Darby 18 Dyar Deposition Exhibit 2 a document entitled 19 "Expert Report of M. Darby Dyar, Ph.D., for 20 General Causation, Daubert Hearing." 21 Can you take a look at this 22 document and tell me what it is? 23 A. This is my report. 24 Q. And it has a copy of your CV 25 attached to the back of it as Exhibit B?</p>	<p>1 determine whether they have asbestos in them? 2 A. Other than the depositions 3 taken this year, no. 4 Q. And the depositions that were 5 taken this year was a one-day deposition 6 taken February 5th or 6th of 2019? 7 A. I believe that's correct. 8 Q. Were you aware that Dr. Longo 9 has testified dozens of times about -- in 10 courtrooms with judges, both federal and 11 state present, about the methodology he 12 follows to analyze the presence of asbestos 13 fibers in materials? 14 A. That's what he says in his -- 15 in the beginning of his most recent 16 deposition, yes. 17 Q. And you didn't ask to review 18 any of that testimony where he describes what 19 he does or how his lab works in detail? 20 A. The current deposition makes it 21 clear that his methodology has remained 22 constant, and so it wasn't necessary to 23 review previous methodologies. 24 Q. What is your understanding of 25 what an expert witness report like Exhibit 2</p>
Page 23	Page 25
<p>1 Exhibit A, excuse me. 2 A. Yes. 3 Q. Did you, as part of your work 4 in this case, ask to see the same samples 5 that Dr. Longo in his laboratory analyzed, 6 have those sent to you so you could analyze 7 them yourself? 8 A. No. 9 Q. Why not? 10 A. My job here was to review the 11 methodology employed by Drs. Longo and 12 Rigler. It was not to do testing. 13 Q. Did you review any testimony of 14 Dr. Longo other than his deposition taken in 15 this case in February of this year? 16 A. No. 17 Q. Did you review any of Mark 18 Rigler's testimony other than his deposition 19 taken in connection with these cases in 20 February of this year? 21 A. No. 22 Q. So am I correct that you have 23 never reviewed testimony of Dr. Longo where 24 he describes his methodology generally that 25 his lab follows for analyzing substances to</p>	<p>1 is for? 2 A. It is to present the opinion of 3 an expert witness on matters that they are 4 asked to evaluate. 5 Q. Do you have the understanding 6 that it is supposed to set forth your 7 opinions and the bases for your opinions on 8 various topics? 9 A. Yes. 10 MR. FINCH: Let's mark as 11 Exhibit 3 -- and I don't have a hard 12 copy with me because I just got it by 13 e-mail last night -- the production 14 materials that were sent to us at 15 5:50 p.m. 16 And could I switch to the iPad? 17 VIDEOGRAPHER: No problem. 18 MR. FINCH: And we'll send this 19 to the court reporter electronically. 20 (Dyar Exhibit 3 marked for 21 identification.) 22 MR. CHACHKES: We have paper 23 copies here. 24 MR. FINCH: If you've got a 25 paper copy you can hand to me, that</p>

7 (Pages 22 to 25)

Melinda Darby Dyar, Ph.D.

Page 26	Page 28
<p>1 would probably speed up the process a 2 little bit. 3 MR. CHACHKES: We could 4 actually have it -- so if we want one 5 for the witness as well -- so we've 6 got one copy. We can take a break 7 and -- 8 MR. FINCH: I don't want to 9 take a break. 10 MR. CHACHKES: Okay. 11 MR. FINCH: I'll come back to 12 it. But I'm going to ask a few 13 questions now, and then if you can, at 14 a break -- 15 QUESTIONS BY MR. FINCH: 16 Q. Okay. Ma'am, can you see the 17 screen here that I'm flipping? 18 A. No. 19 Q. There's a screen in front of 20 you. 21 A. That's way too small. 22 Q. Okay. 23 A. I can certainly use the paper 24 copy. 25 MR. CHACHKES: So I've got the</p>	<p>1 and calculations that you've made and set 2 forth in the report, Exhibit 2? 3 A. Yes, they are. 4 Q. So basically if I want to check 5 your math, I look at the spreadsheets, right? 6 A. Correct. 7 Q. Okay. So you said you were 8 first contacted sometime last fall by a 9 lawyer named Christopher Caryl from the 10 Tucker Ellis law firm about doing expert 11 witness work for Johnson & Johnson; is that 12 correct? 13 A. That is correct. 14 Q. And I have on the screen here, 15 which you probably can flip to, a series of 16 invoices beginning in November of 2018 which 17 reflects work done in October, all the way up 18 through a March 4th invoice which reflects 19 work done in February of 2019. 20 Do you see those invoices? 21 A. I do see them, yes. 22 Q. Okay. My document isn't page 23 numbered, but on the screen there is a 24 contract signed by you on behalf of your 25 company and Johnson & Johnson.</p>
Page 27	Page 29
<p>1 paper copy. 2 MR. FINCH: All right. Counsel 3 for Johnson & Johnson kindly provided 4 the witness with his copy. 5 QUESTIONS BY MR. FINCH: 6 Q. But suffice it to say, did you 7 have the understanding that some additional 8 material was provided to us yesterday in 9 connection with the subpoena you got? 10 A. Yes. 11 Q. Okay. What is your 12 understanding of what was provided to us? 13 A. I believe it was copies of my 14 bills and a copy of my updated CV. 15 Q. Okay. And also contained 16 some -- 17 A. Oh, and -- okay, go ahead. 18 Q. I've got your bills. I've got 19 your updated CV. 20 What is the material, say, the 21 last hundred pages, hundred-plus pages, of 22 the document? 23 A. Those would be my spreadsheets. 24 Q. Okay. Are those the 25 spreadsheets that underlie the conclusions</p>	<p>1 Do you see that? 2 A. Yes. 3 Q. Okay. You started working on 4 this project before the contract was signed. 5 Why is that? 6 A. Because I -- before this 7 contract was signed, because I -- it took me 8 a while to get the legal paperwork for 9 Palouse Minerals organized and approved by 10 Massachusetts. 11 Q. Okay. So you had to set up the 12 LLC. You started doing work, you set up the 13 LLC, and once that was set up, you had 14 Johnson & Johnson's attorneys enter into a 15 contract with you on behalf of LLC, correct? 16 A. Correct. 17 Q. Okay. The first invoice I have 18 here reflects work done in October, and it 19 has an entry for 19 hours and 18 hours, both 20 billed at \$500 an hour, for a total of 21 18,500. 22 Do you see that? 23 A. Yes. 24 Q. Okay. What is the 19 hours and 25 what is the 18 hours?</p>

8 (Pages 26 to 29)

Melinda Darby Dyar, Ph.D.

Page 30	Page 32
<p>1 MR. CHACHKES: Objection.</p> <p>2 Are you asking what's been</p> <p>3 redacted?</p> <p>4 MR. FINCH: Well, I'm asking</p> <p>5 if -- is the redaction basically a</p> <p>6 description of the work, or is the</p> <p>7 redaction the name of a person?</p> <p>8 MR. CHACHKES: So you can --</p> <p>9 I'm going to object on work product</p> <p>10 grounds.</p> <p>11 You can answer on a general</p> <p>12 high level.</p> <p>13 THE WITNESS: Can you restate</p> <p>14 that question, please?</p> <p>15 QUESTIONS BY MR. FINCH:</p> <p>16 Q. Yeah.</p> <p>17 There's a breakdown between 19</p> <p>18 and 18 hours. Is all the work in all these</p> <p>19 invoices performed by you?</p> <p>20 A. Absolutely, yes.</p> <p>21 Q. Okay. So there's nobody else</p> <p>22 that's done any work on this expert witness</p> <p>23 report or your analysis of Dr. Longo and</p> <p>24 Dr. Rigler's reports, correct?</p> <p>25 A. No.</p>	<p>1 object on work product grounds. The</p> <p>2 communications with Professor Dyar are</p> <p>3 going to be privileged, so I'm going</p> <p>4 to ask the witness not to respond to</p> <p>5 this line of questioning.</p> <p>6 MR. FINCH: So noted.</p> <p>7 QUESTIONS BY MR. FINCH:</p> <p>8 Q. Did any lawyers for Johnson &</p> <p>9 Johnson suggest areas of inquiry for you as</p> <p>10 part of your analysis of Dr. Longo's work?</p> <p>11 MR. CHACHKES: So same</p> <p>12 objection.</p> <p>13 Please don't respond.</p> <p>14 QUESTIONS BY MR. FINCH:</p> <p>15 Q. Did any lawyers for Johnson &</p> <p>16 Johnson provide you with any of the pictures</p> <p>17 that appear in your report?</p> <p>18 A. Some of the images in my report</p> <p>19 come from the Longo, Rigler reports. So to</p> <p>20 the extent that I received the Longo and</p> <p>21 Rigler reports from counsel, then, yes, some</p> <p>22 of the images came from there.</p> <p>23 Q. Did you review all of the, for</p> <p>24 lack of a better word, backup material for</p> <p>25 all of the Longo and Rigler reports?</p>
Page 31	Page 33
<p>1 Q. Did you confer with anyone in</p> <p>2 connection with your review of Dr. Longo's --</p> <p>3 and rather than saying Longo and Rigler again</p> <p>4 and again and again, I'm just going to say</p> <p>5 Longo.</p> <p>6 Did you confer with anyone in</p> <p>7 connection with your review of Dr. Longo's</p> <p>8 reports or your writing of your report?</p> <p>9 MR. CHACHKES: Objection.</p> <p>10 THE WITNESS: Yes.</p> <p>11 QUESTIONS BY MR. FINCH:</p> <p>12 Q. Who did you confer with?</p> <p>13 A. Counsel.</p> <p>14 Q. That would be lawyers for</p> <p>15 Johnson & Johnson?</p> <p>16 A. Yes.</p> <p>17 Q. Did you share drafts with them</p> <p>18 of your report?</p> <p>19 A. Yes.</p> <p>20 Q. Did they provide comments on</p> <p>21 the drafting?</p> <p>22 A. Yes.</p> <p>23 Q. Did you consider their</p> <p>24 suggestions in writing your report?</p> <p>25 MR. CHACHKES: So I'm going to</p>	<p>1 A. I looked at every single page.</p> <p>2 Q. Did you look at every single</p> <p>3 photograph or photomicrograph on every single</p> <p>4 page of Dr. Rigler and Dr. Longo's backup</p> <p>5 materials to their reports?</p> <p>6 A. Yes.</p> <p>7 Q. Did you confer with anyone else</p> <p>8 on either your analysis of Dr. Longo and</p> <p>9 Rigler's work or your report, other than</p> <p>10 Johnson & Johnson's lawyers?</p> <p>11 A. Yes.</p> <p>12 Q. Who did you confer with?</p> <p>13 A. Dr. Mickey Gunther.</p> <p>14 Q. Who else?</p> <p>15 A. No one else.</p> <p>16 Q. Did Dr. Gunther provide any</p> <p>17 written comments or suggestions to you in</p> <p>18 your work analysis -- your work in this case?</p> <p>19 MR. CHACHKES: So again, I'm</p> <p>20 going to object on work product</p> <p>21 grounds. Dr. Gunther is a consultant</p> <p>22 for J&J, so I'm going to ask the</p> <p>23 witness not to respond to this line.</p> <p>24 MR. FINCH: Well, we disagree</p> <p>25 with that, but we'll take it up at the</p>

Melinda Darby Dyar, Ph.D.

Page 34	Page 36
<p>1 appropriate time.</p> <p>2 QUESTIONS BY MR. FINCH:</p> <p>3 Q. Did you review Dr. Campion's</p> <p>4 report and publications in connection with</p> <p>5 your work in this case?</p> <p>6 A. I did look at them, yes.</p> <p>7 Q. Did you come to any conclusions</p> <p>8 about them?</p> <p>9 MR. CHACHKES: So I'm going to</p> <p>10 object to this on work product</p> <p>11 grounds. To the extent there were any</p> <p>12 communications, it was not with</p> <p>13 respect to this report.</p> <p>14 QUESTIONS BY MR. FINCH:</p> <p>15 Q. You don't intend to testify</p> <p>16 about any conclusions related to</p> <p>17 Dr. Campion's report?</p> <p>18 A. My purpose here was to review</p> <p>19 only the Longo and Rigler reports.</p> <p>20 Q. In November of 2018, you sent</p> <p>21 an invoice for 37 hours of work -- for work</p> <p>22 done in October of 2018.</p> <p>23 What were you reviewing or</p> <p>24 doing during that 37 hours given that</p> <p>25 Dr. Longo didn't issue his first report in</p>	<p>1 A. That's correct.</p> <p>2 Q. Okay. So in total you've</p> <p>3 billed over \$150,000 to this project so far,</p> <p>4 at least as of the end of February 2019?</p> <p>5 A. I haven't done the math, but</p> <p>6 that seems about right.</p> <p>7 Q. How much time have you spent in</p> <p>8 March of 2019 working on this project?</p> <p>9 A. I don't really know, but not</p> <p>10 much. I wouldn't like to speculate without</p> <p>11 checking my records.</p> <p>12 Q. More than 20 hours?</p> <p>13 A. Yes.</p> <p>14 Q. More than 50 hours?</p> <p>15 A. Probably no.</p> <p>16 Q. How about in April?</p> <p>17 I know it's only the 2nd day of</p> <p>18 April, but did you spend any time yesterday?</p> <p>19 A. Yes.</p> <p>20 Q. What did you do yesterday as</p> <p>21 part of your work for Johnson & Johnson in</p> <p>22 this case?</p> <p>23 MR. CHACHKES: So again, I'm</p> <p>24 going to object on work product</p> <p>25 grounds, but you can answer on a very</p>
Page 35	Page 37
<p>1 the MDL until the middle of November?</p> <p>2 A. I was reviewing prior</p> <p>3 documents, prior reports, of Dr. Longo.</p> <p>4 Q. You mean his reports done in</p> <p>5 connection with state court asbestos</p> <p>6 litigation from 2018, earlier in 2018 and</p> <p>7 partially in 2017?</p> <p>8 A. Let's have a look at the list</p> <p>9 of documents that I included in my report.</p> <p>10 Q. You're looking at Exhibit</p> <p>11 Number 3 -- 2, Exhibit Number 2.</p> <p>12 A. So the first document was</p> <p>13 produced in March -- on March 11, 2018.</p> <p>14 Q. Uh-huh.</p> <p>15 A. Another document was produced</p> <p>16 on September 6th of 2018, and another one was</p> <p>17 produced in September of 2017. So those</p> <p>18 documents were available to me immediately.</p> <p>19 And then when the October 2018 document</p> <p>20 became available, it was given to me.</p> <p>21 Q. So your November invoice was</p> <p>22 for \$18,500; December, 30,000; January,</p> <p>23 25,500; February invoice for January work,</p> <p>24 35,000; and then your March invoice for</p> <p>25 February work was 63,000. Is that correct?</p>	<p>1 high level.</p> <p>2 THE WITNESS: I prepared for</p> <p>3 this deposition.</p> <p>4 QUESTIONS BY MR. FINCH:</p> <p>5 Q. And what did you do to prepare</p> <p>6 for this deposition?</p> <p>7 MR. CHACHKES: Again, I'm going</p> <p>8 to object on work product grounds and</p> <p>9 maybe counsel the witness not to</p> <p>10 answer.</p> <p>11 If you have any specific</p> <p>12 questions that don't threaten the work</p> <p>13 product protections, then you can ask</p> <p>14 those.</p> <p>15 MR. FINCH: I'll leave the</p> <p>16 question as it is.</p> <p>17 MR. CHACHKES: Okay. So please</p> <p>18 don't answer.</p> <p>19 QUESTIONS BY MR. FINCH:</p> <p>20 Q. On the invoices where it says</p> <p>21 "redacted" in several places, can you tell me</p> <p>22 generally what kind of information was</p> <p>23 redacted?</p> <p>24 Is it information relating to</p> <p>25 what you were doing, or is it information</p>

10 (Pages 34 to 37)

Melinda Darby Dyar, Ph.D.

Page 38	Page 40
<p>1 like Social Security numbers or something</p> <p>2 like that?</p> <p>3 A. It's information related to</p> <p>4 what I was doing.</p> <p>5 Q. Okay. So it describes the</p> <p>6 tasks that you were performing in connection</p> <p>7 with your expert witness work in this case?</p> <p>8 A. Correct.</p> <p>9 MR. FINCH: All right. We</p> <p>10 would make a request for an unredacted</p> <p>11 version of the invoices.</p> <p>12 MR. CHACHKES: We'll take it</p> <p>13 under advisement.</p> <p>14 MS. SHARKO: Any requests,</p> <p>15 please put in writing.</p> <p>16 MR. FINCH: Okay. This is</p> <p>17 writing, since someone's writing it</p> <p>18 down, but we will do it in a letter.</p> <p>19 MS. SHARKO: Okay. And keep in</p> <p>20 mind that we will then reciprocate.</p> <p>21 QUESTIONS BY MR. FINCH:</p> <p>22 Q. Let's just get some terms on</p> <p>23 the record.</p> <p>24 What does EDS, EDXA stand for?</p> <p>25 A. Energy-dispersive spectrometry,</p>	<p>1 microscope, and it is possible for the</p> <p>2 analyst to rotate it in various dimensions</p> <p>3 and directions?</p> <p>4 A. Yes, that is correct, and as</p> <p>5 described in the quotation on page 31 of my</p> <p>6 report.</p> <p>7 Q. And so -- which quotation are</p> <p>8 you referring to?</p> <p>9 A. The quotation from ISO 2262-1</p> <p>10 {sic} on page 65 which describes the process</p> <p>11 by which you align a sample for an SAED</p> <p>12 pattern.</p> <p>13 Q. Okay. And am I correct that</p> <p>14 that is something that the analyst, when</p> <p>15 looking at the substance or the structure</p> <p>16 through the TEM, is rotating the material in</p> <p>17 realtime and deciding when to make an image</p> <p>18 of that?</p> <p>19 A. Correct.</p> <p>20 Q. And is it correct that an</p> <p>21 analyst, in reviewing the structure or</p> <p>22 substance in realtime, can decide to take an</p> <p>23 image of the selected area of diffraction</p> <p>24 pattern whenever, in his or her judgment, he</p> <p>25 finds something worth capturing?</p>
Page 39	Page 41
<p>1 or spectroscopy, depending on how you define</p> <p>2 it, and then other people call it</p> <p>3 energy-dispersive X-ray analysis. They're</p> <p>4 general terms for the same thing.</p> <p>5 Q. And am I correct that that is a</p> <p>6 test for elemental chemistry?</p> <p>7 A. It's a qualitative test for</p> <p>8 elemental chemistry.</p> <p>9 Q. Qualitative,</p> <p>10 q-u-a-l-i-t-a-t-a-v-e {sic}?</p> <p>11 A. Correct.</p> <p>12 Q. And that is an analysis</p> <p>13 performed by a transmission electron</p> <p>14 microscope, correct?</p> <p>15 A. Yes.</p> <p>16 Q. Explain what is SAED.</p> <p>17 A. SAED refers to a kind of</p> <p>18 electron diffraction done on a TEM in which</p> <p>19 the electrons are passed through the sample</p> <p>20 and they are diffracted, resulting in a</p> <p>21 pattern.</p> <p>22 Q. And am I correct that when a</p> <p>23 sample is analyzed under SAED, the material</p> <p>24 is placed, for lack of a better word, on the</p> <p>25 plate of the transmission electron</p>	<p>1 MR. CHACHKES: Objection.</p> <p>2 THE WITNESS: That would be a</p> <p>3 standard operating procedure, yes.</p> <p>4 QUESTIONS BY MR. FINCH:</p> <p>5 Q. So a standard operating</p> <p>6 procedure would be the analyst takes the</p> <p>7 substance or material and has the ability to</p> <p>8 rotate it in three dimensions and analyze the</p> <p>9 crystal structure of the material under the</p> <p>10 TEM, correct?</p> <p>11 A. It's not a full three</p> <p>12 dimensions, but it's basically a plane that</p> <p>13 has the ability to be tilted by a small</p> <p>14 number of degrees in various directions.</p> <p>15 Q. Okay. And in the process of</p> <p>16 doing that, the analyst can spend as much or</p> <p>17 as little time as it takes him or her to look</p> <p>18 at the structure or material in the various</p> <p>19 dimensions and take a picture, for lack of a</p> <p>20 better word, of the diffraction pattern at</p> <p>21 whatever points in time he or she thinks are</p> <p>22 important, correct?</p> <p>23 A. Correct.</p> <p>24 Q. And it's -- it is in some sense</p> <p>25 the judgment of the analysts at what point in</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 42</p> <p>1 time he or she takes the picture of the</p> <p>2 selected area of diffraction pattern,</p> <p>3 correct?</p> <p>4 A. Yes.</p> <p>5 Q. You have degrees in geology and</p> <p>6 art history; is that correct?</p> <p>7 A. Correct.</p> <p>8 Q. You have a Ph.D. in geology?</p> <p>9 A. My Ph.D. is actually in</p> <p>10 geochemistry.</p> <p>11 Q. In geochemistry.</p> <p>12 And how did you first get</p> <p>13 interested in geology?</p> <p>14 A. I don't actually recall. I</p> <p>15 think when I was 2 years old, my mother</p> <p>16 reports that I picked up rocks instead of</p> <p>17 Easter eggs on an egg hunt. That was the</p> <p>18 first indication that maybe geology was in my</p> <p>19 future.</p> <p>20 Q. You graduated with a bachelor's</p> <p>21 of art in geology and art history from</p> <p>22 Wellesley College, correct?</p> <p>23 A. As it says in my résumé, when</p> <p>24 I -- at the time I graduated, my BA was in</p> <p>25 geology, and I finished the course</p>	<p style="text-align: right;">Page 44</p> <p>1 diseases?</p> <p>2 A. No.</p> <p>3 Q. You're not a toxicologist?</p> <p>4 A. No.</p> <p>5 Q. Have you ever performed an</p> <p>6 animal study in the sense of either having an</p> <p>7 animal ingest or inhale or otherwise come</p> <p>8 into contact with a substance to determine</p> <p>9 whether that substance has hazardous effects?</p> <p>10 A. No.</p> <p>11 Q. I take it you do not have an</p> <p>12 expert opinion as to whether any of the</p> <p>13 materials found in Johnson & Johnson's talc</p> <p>14 or Johnson & Johnson's baby powder are</p> <p>15 carcinogenic?</p> <p>16 A. I have no opinion on that.</p> <p>17 Q. You have no expert opinion</p> <p>18 regarding whether any amphiboles found in</p> <p>19 talc from New York, the Gouverneur talc mine,</p> <p>20 are carcinogenic; is that correct?</p> <p>21 MR. LOCKE: Objection.</p> <p>22 THE WITNESS: I have no opinion</p> <p>23 on that.</p> <p>24 QUESTIONS BY MR. FINCH:</p> <p>25 Q. Do you have any opinion about</p>
<p style="text-align: right;">Page 43</p> <p>1 requirements for the art history degree while</p> <p>2 I was enrolled at MIT subsequent to my</p> <p>3 graduation from Wellesley.</p> <p>4 Q. And you got your Ph.D. in</p> <p>5 geochemistry from MIT, correct?</p> <p>6 A. Correct.</p> <p>7 Q. You're not an epidemiologist,</p> <p>8 correct?</p> <p>9 A. No.</p> <p>10 Q. You're not a medical doctor?</p> <p>11 A. No.</p> <p>12 Q. You don't hold yourself out as</p> <p>13 an expert on the biological activity of</p> <p>14 substances in the human body; is that</p> <p>15 correct?</p> <p>16 A. No.</p> <p>17 Q. You're not a cell biologist?</p> <p>18 A. I work with a microbiologist</p> <p>19 and I have written papers on microbiology,</p> <p>20 but I don't consider myself a cell biologist,</p> <p>21 no.</p> <p>22 Q. Do you hold yourself out as an</p> <p>23 expert in analyzing whether or not and how</p> <p>24 fibers and structures can cause genetic</p> <p>25 errors which lead to cancer or other</p>	<p style="text-align: right;">Page 45</p> <p>1 whether the amphiboles found in Libby</p> <p>2 vermiculite are carcinogenic?</p> <p>3 A. I have no opinion on that.</p> <p>4 Q. You have no expert opinion on</p> <p>5 that?</p> <p>6 A. No.</p> <p>7 Q. Are you familiar with the fact</p> <p>8 that there has been an epidemic of</p> <p>9 mesothelioma in and around Libby, Montana?</p> <p>10 MR. FROST: Objection.</p> <p>11 MR. LOCKE: Objection.</p> <p>12 THE WITNESS: Vaguely.</p> <p>13 QUESTIONS BY MR. FINCH:</p> <p>14 Q. How did you come to that</p> <p>15 understanding?</p> <p>16 MR. FROST: Objection.</p> <p>17 THE WITNESS: I read it in a</p> <p>18 newspaper maybe?</p> <p>19 QUESTIONS BY MR. FINCH:</p> <p>20 Q. When was the first time you met</p> <p>21 Mickey Gunther?</p> <p>22 A. In the summer of 1996, I met</p> <p>23 Mickey at a teaching mineralogy workshop at</p> <p>24 Smith College.</p> <p>25 Q. Were you on the faculty of that</p>

Melinda Darby Dyar, Ph.D.

Page 46	Page 48
<p>1 workshop, or was he on the faculty of that</p> <p>2 workshop? How did you come in contact?</p> <p>3 A. I was driving a van on the</p> <p>4 field trip, and Mickey got in and sat next to</p> <p>5 me.</p> <p>6 Q. And since that time, you have</p> <p>7 collaborated on both a textbook and about,</p> <p>8 what, 30 papers, something like that?</p> <p>9 A. I don't keep count of the</p> <p>10 papers, but they're all as listed in my CV.</p> <p>11 Q. Could you identify for me your</p> <p>12 peer-review publications which address the</p> <p>13 subject of how to determine if a material is</p> <p>14 asbestos in the environment?</p> <p>15 MR. CHACHKES: Objection.</p> <p>16 THE WITNESS: I would have to</p> <p>17 spend some time going through the list</p> <p>18 to see if there are any that satisfy</p> <p>19 those criteria. I don't recall.</p> <p>20 QUESTIONS BY MR. FINCH:</p> <p>21 Q. Can you think of any off the</p> <p>22 top of your head right now?</p> <p>23 A. No.</p> <p>24 Q. Have you ever published a</p> <p>25 peer-review publication regarding how to</p>	<p>1 me back up.</p> <p>2 Have you ever been in charge of</p> <p>3 a laboratory where the laboratory regularly</p> <p>4 tested materials to determine if they</p> <p>5 contained asbestos?</p> <p>6 A. No.</p> <p>7 Q. Have you analyzed over 300</p> <p>8 samples of material -- 300,000 samples of</p> <p>9 materials over the course of your career to</p> <p>10 detect whether or not asbestos was present in</p> <p>11 them?</p> <p>12 A. No.</p> <p>13 Q. Have you ever been recognized</p> <p>14 by a court as an expert witness on the</p> <p>15 subject of examining material to determine</p> <p>16 whether it contained asbestos?</p> <p>17 A. No.</p> <p>18 Q. Have you ever served as an</p> <p>19 expert consultant for the City of New York,</p> <p>20 the State of New York, the State of Utah or</p> <p>21 any other governmental entity on the subject</p> <p>22 of examining material to determine whether it</p> <p>23 contained asbestos?</p> <p>24 A. No.</p> <p>25 Q. Have you ever been the primary</p>
Page 47	Page 49
<p>1 determine if there is asbestos in a product?</p> <p>2 A. Not that I recall.</p> <p>3 Q. Have you published any</p> <p>4 peer-review articles regarding the use of --</p> <p>5 I'm just going to use the shorthand term --</p> <p>6 EDS, EDXA, to identify asbestos in materials?</p> <p>7 A. Not that I recall.</p> <p>8 Q. Have you ever authored a</p> <p>9 peer-review publication concerning the use of</p> <p>10 selected area diffraction -- selected area</p> <p>11 electron diffraction, SAED, to identify</p> <p>12 asbestos in materials?</p> <p>13 A. Not that I recall.</p> <p>14 Q. Have you ever published a</p> <p>15 peer-review paper regarding the use of</p> <p>16 polarized light microscopy, PLM, to</p> <p>17 distinguish between asbestos in talc in</p> <p>18 materials?</p> <p>19 A. Not that I recall.</p> <p>20 Q. Have you ever been asked by the</p> <p>21 United States Environmental Protection Agency</p> <p>22 to draft standards relating to the</p> <p>23 identification of asbestos in a material?</p> <p>24 A. No.</p> <p>25 Q. Have you or laboratories -- let</p>	<p>1 author of an American Society Testing and</p> <p>2 Materials method for the analysis of asbestos</p> <p>3 fibers and bundles in settled dust?</p> <p>4 A. No.</p> <p>5 Q. Have you ever been the primary</p> <p>6 author of any ASTM memorandum?</p> <p>7 A. No.</p> <p>8 Q. You cite to several different</p> <p>9 ISO memorandums relating to the</p> <p>10 identification of asbestos in either bulk</p> <p>11 samples or in the air or in talc, correct?</p> <p>12 A. Correct.</p> <p>13 Q. Have you ever been the author</p> <p>14 or a contributor to an ISO memorandum</p> <p>15 relating to the identification of asbestos in</p> <p>16 bulk samples?</p> <p>17 A. No.</p> <p>18 Q. Have you ever been the author</p> <p>19 or contributor to an ISO memorandum relating</p> <p>20 to the identification of asbestos in the air?</p> <p>21 A. No.</p> <p>22 Q. Have you ever been the author</p> <p>23 or contributor to an ISO memorandum relating</p> <p>24 to the identification of asbestos in talc?</p> <p>25 A. No.</p>

13 (Pages 46 to 49)

Melinda Darby Dyar, Ph.D.

Page 50	Page 52
<p>1 Q. Have you ever tested a sample</p> <p>2 of talc to determine whether or not it</p> <p>3 contained asbestos?</p> <p>4 A. No.</p> <p>5 Q. Have you ever published</p> <p>6 anything in any peer-reviewed journal about</p> <p>7 testing talc to determine if it contains</p> <p>8 asbestos?</p> <p>9 A. No.</p> <p>10 Q. What -- and I'm going to</p> <p>11 butcher this word repeatedly because it's</p> <p>12 just one of those words I just cannot say.</p> <p>13 But what microscopy-based spectroscopic</p> <p>14 methods have you used over the course of your</p> <p>15 career?</p> <p>16 A. Oh, Mössbauer spectroscopy,</p> <p>17 electron spectroscopy of various kinds, TEM,</p> <p>18 SEM, electron probe microanalysis, X-ray</p> <p>19 diffraction, X-ray fluorescence,</p> <p>20 proton-induced gamma emission, laser-induced</p> <p>21 breakdown spectroscopy, Raman spectroscopy.</p> <p>22 Those are some of them.</p> <p>23 Q. Do you oversee a lab currently</p> <p>24 that has electron microscopes?</p> <p>25 A. No. The lab that contains an</p>	<p>1 two of them were -- happen to be those</p> <p>2 standards. I don't recall.</p> <p>3 Q. How many -- what is the primary</p> <p>4 laboratory that you've worked with over the</p> <p>5 past ten years?</p> <p>6 Is it the Mount Holyoke?</p> <p>7 A. My research takes place at many</p> <p>8 different institutions. I work with the</p> <p>9 synchrotron at the Advanced Photo Source,</p> <p>10 Photon Source, in Chicago. I work with</p> <p>11 scientists at Los Alamos National Laboratory,</p> <p>12 and I work with scientists at the University</p> <p>13 of Massachusetts in Amherst where I am on the</p> <p>14 graduate faculty.</p> <p>15 My own laboratory at Mount</p> <p>16 Holyoke also includes many different kinds of</p> <p>17 spectrometers.</p> <p>18 Q. And your own laboratory at</p> <p>19 Mount Holyoke has a SEM and a TEM now?</p> <p>20 A. No. As I stated, Mount Holyoke</p> <p>21 has an analytical facility for TEM and SEM,</p> <p>22 which is under the direction of the director</p> <p>23 of science center.</p> <p>24 Q. And the science center is</p> <p>25 affiliated with what entity?</p>
Page 51	Page 53
<p>1 SEM and TEM at Mount Holyoke is overseen by</p> <p>2 the director of the science center.</p> <p>3 Q. Do you have access to that lab?</p> <p>4 A. Yes.</p> <p>5 Q. Can you list the various types</p> <p>6 of electron microscopes you have used to</p> <p>7 analyze materials over the years?</p> <p>8 A. You want to clarify what you</p> <p>9 mean by "type"?</p> <p>10 Q. Well, the manufacturer, the</p> <p>11 model.</p> <p>12 A. No, I don't pay attention to</p> <p>13 that. I'd have to go back and look at the</p> <p>14 papers.</p> <p>15 Q. Are you aware that the National</p> <p>16 Bureau of Standards publishes asbestos</p> <p>17 standards?</p> <p>18 A. Yes.</p> <p>19 Q. Have you analyzed the National</p> <p>20 Bureau of Standards asbes -- standard</p> <p>21 asbestos samples in any laboratory where</p> <p>22 you've worked?</p> <p>23 A. I can't recall. I've analyzed</p> <p>24 hundreds of thousands of samples in my</p> <p>25 career, so it's difficult to recall if one or</p>	<p>1 A. All of the science departments</p> <p>2 at the college.</p> <p>3 Q. Okay. Do you know what NVLAP</p> <p>4 NIST accredited means?</p> <p>5 A. I know what NIST stands for.</p> <p>6 Q. Do you know if any of the</p> <p>7 laboratories you've worked in are NVLAP NIST</p> <p>8 accredited?</p> <p>9 A. So academic institutions are</p> <p>10 accredited by completely differently</p> <p>11 organizations than the ones that are used for</p> <p>12 business entities.</p> <p>13 And, yes, Mount Holyoke does</p> <p>14 have an accreditation.</p> <p>15 Q. Have you ever calibrated an</p> <p>16 electron microscope for electron diffraction?</p> <p>17 A. Probably 30 years ago, yes.</p> <p>18 Q. You haven't done it in the past</p> <p>19 30 years?</p> <p>20 A. Our equipment is already kept</p> <p>21 well-calibrated. We have a full-time</p> <p>22 laboratory manager who takes care of the EMs.</p> <p>23 Q. Have any of the labs that you</p> <p>24 have worked with or for been in the NVLAP</p> <p>25 NIST program for the identification of</p>

14 (Pages 50 to 53)

Melinda Darby Dyar, Ph.D.

Page 54	Page 56
<p>1 asbestos?</p> <p>2 A. I have no knowledge of that.</p> <p>3 Q. How much time do you spend on a</p> <p>4 daily basis analyzing materials to determine</p> <p>5 whether or not they contain asbestos fibers?</p> <p>6 A. Zero.</p> <p>7 Q. How much time do you spend on a</p> <p>8 weekly basis analyzing materials to determine</p> <p>9 whether or not they contain asbestos?</p> <p>10 A. Zero.</p> <p>11 Q. How much time do you spend on a</p> <p>12 yearly basis analyzing materials to determine</p> <p>13 whether or not they contain asbestos?</p> <p>14 A. Zero.</p> <p>15 Q. What are the steps for</p> <p>16 identifying and assessing whether a sample of</p> <p>17 a material contains asbestos?</p> <p>18 A. Well, let's go back to my</p> <p>19 report where that's articulated quite</p> <p>20 clearly.</p> <p>21 So, for example, my report</p> <p>22 talks about the Yamate -- the Yamate document</p> <p>23 from the EPA, it talks about the ISO 22262</p> <p>24 document, and it also talks about PLM methods</p> <p>25 explained and described in the Su documents.</p>	<p>1 be reliable standards that a scientist should</p> <p>2 follow for analyzing whether or not a sample</p> <p>3 of a material contains asbestos?</p> <p>4 A. I would say that in the case of</p> <p>5 determination of bulk asbestos, the methods</p> <p>6 in those documents are robust.</p> <p>7 Q. What about for determining</p> <p>8 whether or not there is asbestos in talc?</p> <p>9 A. So those -- so Document 1, for</p> <p>10 example, which you mentioned, explicitly says</p> <p>11 it's for measurements of bulk samples, and</p> <p>12 Document Number 3, which is the one relating</p> <p>13 to X-ray diffraction, explicitly says that</p> <p>14 XRD has some limitations. And so ISO</p> <p>15 document 22262-2 is the only one that is</p> <p>16 really relevant to looking at small amounts</p> <p>17 of asbestos.</p> <p>18 Q. Okay. Do you regard the</p> <p>19 standard set forth in ISO 22262-2 to be</p> <p>20 reliable for a scientific -- a scientist to</p> <p>21 follow to analyze whether or not there are</p> <p>22 small amounts of asbestos in talc?</p> <p>23 A. You know, my goal in this</p> <p>24 report was to evaluate whether the</p> <p>25 methodology of Drs. Longo and Rigler was</p>
Page 55	Page 57
<p>1 So there are many different ways of answering</p> <p>2 that question.</p> <p>3 Q. Okay. Do you find the</p> <p>4 methodology set forth in ISO 22262-1 and</p> <p>5 22262-2 to be reliable standards that</p> <p>6 a scientist should follow for analyzing</p> <p>7 whether or not a sample of material contains</p> <p>8 asbestos?</p> <p>9 A. It would depend on -- the</p> <p>10 answer to that question would depend on the</p> <p>11 level of asbestos.</p> <p>12 So you want to be more</p> <p>13 specific?</p> <p>14 Q. Any level.</p> <p>15 A. Want to -- would you please</p> <p>16 restate the question?</p> <p>17 Q. Yes.</p> <p>18 Do you --</p> <p>19 MR. FINCH: Could you read back</p> <p>20 the question, madam court reporter?</p> <p>21 No? Okay. I'll see if I</p> <p>22 can...</p> <p>23 QUESTIONS BY MR. FINCH:</p> <p>24 Q. Do you find the methodology set</p> <p>25 forth in ISO standards 22262-1 and 22262-2 to</p>	<p>1 valid. It was not to evaluate whether the</p> <p>2 government documents on this topic are</p> <p>3 appropriate. So I have not thought about</p> <p>4 that.</p> <p>5 Q. Okay. So you don't -- you</p> <p>6 don't criticize the standards in -- or the</p> <p>7 methodology set forth in ISO 22262-2; is that</p> <p>8 correct?</p> <p>9 A. It's a government document. I</p> <p>10 haven't been asked to think about criticizing</p> <p>11 it, and so I haven't thought about it.</p> <p>12 MR. CHACKES: And we've been</p> <p>13 going about an hour. If you reach a</p> <p>14 natural pausing point, we'll take</p> <p>15 maybe a little break.</p> <p>16 MR. FINCH: Okay. Let me go</p> <p>17 about another five minutes.</p> <p>18 MR. CHACKES: Sure.</p> <p>19 QUESTIONS BY MR. FINCH:</p> <p>20 Q. When was the last sample that</p> <p>21 you analyzed that contained asbestos?</p> <p>22 A. What do you mean by "analyzed"?</p> <p>23 Q. Analyzed using any of the tools</p> <p>24 that a scientist could use to determine</p> <p>25 whether a substance or material contains</p>

15 (Pages 54 to 57)

Melinda Darby Dyar, Ph.D.

Page 58	Page 60
<p>1 asbestos, either a PLM or TEM or any other</p> <p>2 way.</p> <p>3 A. I have in the past year</p> <p>4 undertaken Mössbauer spectroscopy on asbestos</p> <p>5 samples to determine their ferrous ratios,</p> <p>6 but that is unrelated to the question of</p> <p>7 determining whether asbestos is present or</p> <p>8 not because I already knew that SAED samples</p> <p>9 were asbestos.</p> <p>10 Q. Okay. Do you recall when is</p> <p>11 the last time you analyzed a sample where you</p> <p>12 didn't know whether or not asbestos was</p> <p>13 present to determine if, in fact, it</p> <p>14 contained asbestos?</p> <p>15 A. Never.</p> <p>16 Q. Never done that?</p> <p>17 A. No.</p> <p>18 Q. You have -- I think I counted</p> <p>19 this up right; maybe I missed one.</p> <p>20 You have three publications</p> <p>21 that deal with materials found in the</p> <p>22 vermiculite from Libby, Montana; is that</p> <p>23 right?</p> <p>24 A. I contributed Mössbauer</p> <p>25 analyses to three papers, yes. I did not</p>	<p>1 used to evaluate how much oxygen was</p> <p>2 available at the time a mineral crystalized,</p> <p>3 so in particular it's used to measure the</p> <p>4 valent state of iron, whether it is oxidized</p> <p>5 iron, which would be ferric iron, or reduced</p> <p>6 iron, which would be ferrous iron. That is</p> <p>7 one of my specialties.</p> <p>8 Q. So one of your specialties is</p> <p>9 using the Mössbauer analysis to determine,</p> <p>10 for lack of a better word, the iron content</p> <p>11 of something that might have asbestos in it?</p> <p>12 A. One of my specialties is to use</p> <p>13 Mössbauer spectroscopy to determine the iron</p> <p>14 redux ratio of minerals among the 5,500 known</p> <p>15 minerals. That's one of the specialties,</p> <p>16 yes.</p> <p>17 MR. FINCH: All right. This is</p> <p>18 a good time to take a break.</p> <p>19 VIDEOGRAPHER: The time is</p> <p>20 10:05 a.m. Going off the record.</p> <p>21 (Off the record at 10:05 a.m.)</p> <p>22 VIDEOGRAPHER: We are back on</p> <p>23 the record. The time is 10:21 a.m.</p> <p>24 (Dyar Exhibits 4, 5, 6 and 7</p> <p>25 marked for identification.</p>
Page 59	Page 61
<p>1 have anything to do with writing the papers.</p> <p>2 Q. Okay. Your name appears on</p> <p>3 those papers, right?</p> <p>4 A. Correct. Because as is</p> <p>5 appropriate in science, I contributed data to</p> <p>6 the endeavor and, therefore, was included as</p> <p>7 a coauthor.</p> <p>8 Q. And Mickey Gunther is the lead</p> <p>9 author on several -- on those papers, or is</p> <p>10 at least an author on each of those papers?</p> <p>11 A. I don't know. I'd have to</p> <p>12 look, but I would presume so.</p> <p>13 Q. So am I correct that you did</p> <p>14 not analyze any of the material that came</p> <p>15 from the vermiculite from Libby, Montana, to</p> <p>16 determine whether or not it had asbestos in</p> <p>17 it?</p> <p>18 A. Correct. I only analyzed</p> <p>19 things to determine the redux ratios.</p> <p>20 Q. Okay. You mentioned something</p> <p>21 called the Mössbauer spectrum?</p> <p>22 A. Correct.</p> <p>23 Q. All right. Could you describe</p> <p>24 what that is?</p> <p>25 A. A Mössbauer spectrometer is</p>	<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. We're back on the record after</p> <p>3 a short break.</p> <p>4 Do you prefer to be called</p> <p>5 Dr. Darby Dyar or Ms. Darby Dyar?</p> <p>6 A. How about Professor Dyar.</p> <p>7 Q. Okay. Professor Dyar.</p> <p>8 I've marked and put in front of</p> <p>9 both you and your lawyer copies of Darby Dyar</p> <p>10 Exhibit 4, 5, 6 and 7.</p> <p>11 A. Yes.</p> <p>12 Q. And can you tell me what each</p> <p>13 of those is?</p> <p>14 A. So these documents are the air</p> <p>15 quality testing International standard ISO</p> <p>16 22262-1 and 2, and ISO 13794, as well as the</p> <p>17 Yamate report from the EPA dated July 1984.</p> <p>18 Q. Okay.</p> <p>19 What is the International</p> <p>20 Standard Organization?</p> <p>21 A. I don't actually know.</p> <p>22 Q. When is the first time you</p> <p>23 reviewed or saw ISO 22262-1? This is Dyar 4.</p> <p>24 A. When I saw it referenced in</p> <p>25 Dr. Longo's report.</p>

16 (Pages 58 to 61)

Melinda Darby Dyar, Ph.D.

Page 62	Page 64
<p>1 Q. Okay. So you had never</p> <p>2 previously had occasion in your career to</p> <p>3 rely on the International standard for</p> <p>4 sampling and qualitative determination of</p> <p>5 asbestos in commercial bulk materials; is</p> <p>6 that correct?</p> <p>7 A. In my research I use and have</p> <p>8 used these techniques for almost 40 years,</p> <p>9 but I have not yet brought them to bear on</p> <p>10 the study of asbestos as an impurity in</p> <p>11 talcum powder.</p> <p>12 Q. Okay. So you never had the --</p> <p>13 prior to your engagement by Johnson & Johnson</p> <p>14 in this case, you never reviewed the</p> <p>15 methodology set forth in ISO 22262-1; is that</p> <p>16 correct?</p> <p>17 MR. LOCKE: Objection.</p> <p>18 THE WITNESS: Can you state the</p> <p>19 question again?</p> <p>20 QUESTIONS BY MR. FINCH:</p> <p>21 Q. Yeah.</p> <p>22 Prior to being retained by</p> <p>23 Johnson & Johnson as a potential expert in</p> <p>24 these ovarian cancer cases, you never had</p> <p>25 occasion to review ISO 22262-1 and the</p>	<p>1 ISO 22262-1 and ISO 22262-2 lay out the</p> <p>2 methodology -- a methodology for a scientist</p> <p>3 to follow in order to determine whether or</p> <p>4 not for ISO 22262-1, whether or not there's</p> <p>5 asbestos in commercial bulk materials, and</p> <p>6 ISO 22262-2, whether there is asbestos in</p> <p>7 talc?</p> <p>8 A. These two documents do describe</p> <p>9 protocols for analyzing asbestos, yes.</p> <p>10 Q. And if an analyst follows those</p> <p>11 protocols, would you criticize him or her for</p> <p>12 doing so?</p> <p>13 A. So if we go back to my report,</p> <p>14 we'll see numerous places where I talk about</p> <p>15 the proper use of these tools for the</p> <p>16 analysis of asbestos in amphibole.</p> <p>17 Q. But you're not criticizing the</p> <p>18 methodology set forth in ISO 22262-1 or</p> <p>19 22262-2; is that correct?</p> <p>20 A. Do you want to be more specific</p> <p>21 by what you mean about methodology?</p> <p>22 Q. Yeah.</p> <p>23 The steps that they -- the</p> <p>24 ISO -- let's say, ISO 222 -- you agree that</p> <p>25 ISO 22262-1 and ISO 22262-2 lay out the steps</p>
Page 63	Page 65
<p>1 methodology that it lays out for</p> <p>2 determination of asbestos in commercial bulk</p> <p>3 materials; is that correct?</p> <p>4 MR. LOCKE: Objection.</p> <p>5 THE WITNESS: I have never</p> <p>6 reviewed this specific document, but I</p> <p>7 have reviewed countless times the use</p> <p>8 of polarized light microscopy in the</p> <p>9 detection and analysis of minerals.</p> <p>10 It's something I routinely teach and</p> <p>11 it's something that I routinely use in</p> <p>12 my research, but, again, not for the</p> <p>13 purpose of detection of asbestos</p> <p>14 specifically.</p> <p>15 QUESTIONS BY MR. FINCH:</p> <p>16 Q. Am I correct -- well, let me</p> <p>17 just ask it.</p> <p>18 Have you ever reviewed ISO</p> <p>19 Standard 22262-2 prior to your retention by</p> <p>20 Johnson & Johnson in these cases?</p> <p>21 A. No. There was no need.</p> <p>22 MR. FINCH: Move to strike that</p> <p>23 "there was no need."</p> <p>24 QUESTIONS BY MR. FINCH:</p> <p>25 Q. Would you agree with me that</p>	<p>1 that a scientist should follow and the tools</p> <p>2 that the scientist should use to determine</p> <p>3 whether or not there is asbestos in either a</p> <p>4 bulk commercial material or in talc?</p> <p>5 A. I would say that they lay out</p> <p>6 some of these steps that should be used, and</p> <p>7 if done correctly, they would be useful. But</p> <p>8 in my report, I talk about the possible</p> <p>9 downside of many of these methods.</p> <p>10 So, for example, polarized</p> <p>11 light microscopy, if done correctly, can be</p> <p>12 useful in identifying minerals, but for the</p> <p>13 possible -- and for the analysis of possible</p> <p>14 impurities of -- in talcum powder, there are</p> <p>15 many minerals that would have the same PLM</p> <p>16 characteristics, so the results might well be</p> <p>17 inconclusive.</p> <p>18 Q. Am I correct that ISO 22262-2</p> <p>19 lays out a methodology and different tools</p> <p>20 for a scientist to use to determine whether</p> <p>21 or not there is asbestos in talc? Correct?</p> <p>22 A. So 22262, as it states --</p> <p>23 Q. Dash 2.</p> <p>24 A. Dash 2 -- talks about the use</p> <p>25 of gravimetry and microscopic methods, and it</p>

17 (Pages 62 to 65)

Melinda Darby Dyar, Ph.D.

Page 66	Page 68
<p>1 is designed to be used for quantitative 2 analysis of materials that are described on 3 the first page of that document's narrative. 4 Q. Which includes talc, correct? 5 A. Yes, mineral products such as 6 wollastonite, dolomite, calcite, talc or 7 vermiculite. 8 Q. And ISO 22262-2, in some 9 instances, refers back to ISO 22262-1 for how 10 to use the tools or analyze the data that one 11 obtains from using the tools to determine 12 whether what you were analyzing is asbestos 13 or not, correct? 14 A. Yes, these documents reference 15 one another and also other preexisting 16 documents. 17 Q. Okay. Are you familiar with 18 what I've marked as Dyar 6, ISO -- before I 19 get to Dyar 6, am I correct that the first 20 time you reviewed ISO 22262-1 or 22262-2 was 21 in connection with your work as a paid expert 22 work by Johnson & Johnson? 23 A. Yes. As a research scientist, 24 I have no need of anyone to tell me what -- 25 how to use these tools in my own research</p>	<p>1 report for the Environmental Protection 2 Agency? 3 A. That's my understanding, yes. 4 Q. Were you aware that Mr. Yamate 5 at one point worked for Bill Longo? 6 MR. CHACHKES: Objection. 7 THE WITNESS: I have no 8 knowledge of that. 9 QUESTIONS BY MR. FINCH: 10 Q. When is the first time that you 11 reviewed -- or can we just agree that we're 12 going to call Dyar 7 the Yamate report? 13 A. Sure. 14 Q. When's the first time you 15 reviewed the Yamate report? 16 A. For this particular case. 17 Q. You never reviewed it before 18 this? 19 A. No, it wasn't necessary because 20 I already know how to do electron microscopy, 21 as evidenced by my many peer-reviewed 22 publications that use the technique. 23 Q. And would you agree with me 24 that this Yamate report, Dyar 7, lays out 25 three different methodologies called level 1</p>
Page 67	Page 69
<p>1 because I've been trained to use these tools 2 over the course of my 40-year career, so 3 there was no need to consult a standard of 4 this sort. 5 Q. Have you ever reviewed or seen 6 ISO 13794 prior to your engagement by 7 Johnson & Johnson in these cases? 8 A. No, because I had no need for 9 instruction in how to use a TEM or how to do 10 point counting. I already know how to do 11 that in my research as affirmed by my 12 peer-reviewed publications. 13 Q. Are you familiar with Dyar 14 Exhibit 7? 15 A. Yes. 16 Q. What is Dyar Exhibit 7? 17 A. Dyar Exhibit 7 is a methodology 18 from George Yamate, written as an EPA report 19 in 1984. 20 Q. And what is the title of this 21 document? 22 A. The title of this document is 23 "Methodology for the Measurement of Airborne 24 Asbestos By Electron Microscopy." 25 Q. And this was a contracted</p>	<p>1 analysis, level 2 analysis and level 3 2 analysis for determining whether or not there 3 is asbestos in some kind of substance? 4 A. Yes, that's what it says. 5 Q. Do you have any opinion about 6 whether or not following these protocol would 7 be a reliable thing for a scientist to do in 8 analyzing whether there's asbestos in a 9 substance? 10 A. I have an opinion on the fact 11 that Dr. Longo did not follow this guideline. 12 He did not do any of the level 3 protocols 13 expressed in this, including reporting two 14 different zone axis SAED patterns. 15 Q. Am I correct you have not 16 reviewed any Johnson & Johnson internal 17 documents relating to testing it did of 18 either Johnson's baby powder or talc? 19 A. Correct, because my goal in 20 this investigation was to evaluate the 21 methodology of Drs. Longo and Rigler. 22 Q. My colleague, Mr. Geier, 23 pointed out that in the prior question I 24 asked you whether or not you have an opinion 25 about whether or not following the Yamate</p>

18 (Pages 66 to 69)

Melinda Darby Dyar, Ph.D.

Page 70	Page 72
<p>1 protocol would be a reliable thing for a</p> <p>2 scientist to do in analyzing whether there's</p> <p>3 asbestos in a substance.</p> <p>4 And your answer was, "I have an</p> <p>5 opinion on the fact that Dr. Longo did not</p> <p>6 follow this guideline. He did not do any of</p> <p>7 the level 3 protocols expressed in this,</p> <p>8 including reporting two different zone axes</p> <p>9 SAED patterns."</p> <p>10 My question is a little bit</p> <p>11 different. My question is, if a scientist</p> <p>12 follows the Yamate level 3 protocol for the</p> <p>13 number of samples or percentage of samples it</p> <p>14 says to apply that protocol to, would you</p> <p>15 have any criticism of the protocol itself as</p> <p>16 a way for detecting asbestos in talc -- in</p> <p>17 talc or any other substance?</p> <p>18 A. Yes, I would have criticisms</p> <p>19 because SAED only identifies which mineral</p> <p>20 species it is. It does not say anything</p> <p>21 about the morphology of the particle.</p> <p>22 Q. Would you agree with me that</p> <p>23 there are different tests to determine</p> <p>24 whether or not there is asbestos in a sample</p> <p>25 or substance?</p>	<p>1 to identify the mineral species that</p> <p>2 is present. EDS is used to identify</p> <p>3 the chemical composition of what is</p> <p>4 present. Neither of those techniques</p> <p>5 can tell you anything about the</p> <p>6 morphology of the particle that is</p> <p>7 present and, therefore, they are</p> <p>8 not -- those two techniques together</p> <p>9 could not tell you if asbestos was</p> <p>10 present.</p> <p>11 QUESTIONS BY MR. FINCH:</p> <p>12 Q. What technique could -- isn't</p> <p>13 it true that the morphology of the particle</p> <p>14 is examining under a microscope and</p> <p>15 determining things like the shape and size</p> <p>16 and aspect ratio?</p> <p>17 A. True.</p> <p>18 So if SAED, in two different</p> <p>19 zone axis determinations, were combined with</p> <p>20 EDS analyses done properly, as -- as</p> <p>21 expressed in my report, along with a survey</p> <p>22 of the population of particle morphologies</p> <p>23 present was undertaken, if all of those</p> <p>24 things were true, then it would be possible</p> <p>25 to identify something as asbestos.</p>
Page 71	Page 73
<p>1 A. Certainly there are different</p> <p>2 tests that determine the presence of</p> <p>3 asbestos.</p> <p>4 Q. Okay. One of them you</p> <p>5 mentioned was SAED.</p> <p>6 That's to determine the</p> <p>7 crystalline structure, correct?</p> <p>8 MR. CHACHKES: Objection.</p> <p>9 THE WITNESS: SAED can be used</p> <p>10 to determine the mineral species that</p> <p>11 is present in the sample. It's used</p> <p>12 in a very wide variety of</p> <p>13 applications. It cannot prove that</p> <p>14 something is asbestos.</p> <p>15 QUESTIONS BY MR. FINCH:</p> <p>16 Q. It cannot prove by itself that</p> <p>17 something's asbestos, correct?</p> <p>18 A. Correct.</p> <p>19 Q. When used in conjunction with</p> <p>20 other tools such as PLM or TEM, EDS, EDXA,</p> <p>21 isn't it true that you can come to a</p> <p>22 conclusion whether or not a given material is</p> <p>23 asbestos?</p> <p>24 MR. FROST: Objection. Form.</p> <p>25 THE WITNESS: So SAED is used</p>	<p>1 Q. A survey of population of a</p> <p>2 particle, what techniques would you use to do</p> <p>3 that?</p> <p>4 A. So in my report, if we go to</p> <p>5 page -- let's see. It's the section</p> <p>6 beginning on page 52. So it talks here about</p> <p>7 the possibility of using a population of</p> <p>8 particles and analyzing their size to</p> <p>9 determine whether something is asbestos.</p> <p>10 That's -- the word "population"</p> <p>11 is also used in the R-93 document that I</p> <p>12 reviewed, and populations are also referred</p> <p>13 to in the ISO documents, although I can't,</p> <p>14 without further time, tell you exactly which</p> <p>15 one.</p> <p>16 So in these -- in many of these</p> <p>17 documents, they do refer to populations of</p> <p>18 morphologies rather than individual ones.</p> <p>19 Q. Are you aware that Mickey</p> <p>20 Gunther has served as an expert witness for</p> <p>21 multiple defendants in asbestos litigation</p> <p>22 over the years?</p> <p>23 MR. FROST: Objection. Form.</p> <p>24 THE WITNESS: I'm aware that</p> <p>25 Mickey has what he calls his lawyer</p>

19 (Pages 70 to 73)

Melinda Darby Dyar, Ph.D.

Page 74	Page 76
<p>1 work, yes.</p> <p>2 QUESTIONS BY MR. FINCH:</p> <p>3 Q. He's testified at the request</p> <p>4 of W.R. Grace, for example, in cases</p> <p>5 involving its asbestos-containing</p> <p>6 vermiculite?</p> <p>7 MR. CHACHKES: Objection.</p> <p>8 MR. FROST: Objection. Form.</p> <p>9 THE WITNESS: I'm not aware of</p> <p>10 exactly what Mickey does in his lawyer</p> <p>11 work.</p> <p>12 QUESTIONS BY MR. FINCH:</p> <p>13 Q. Are you aware that he always</p> <p>14 works for defendants in asbestos litigation</p> <p>15 and has never worked for a victim in asbestos</p> <p>16 litigation?</p> <p>17 MR. CHACHKES: Objection.</p> <p>18 MR. FROST: Objection.</p> <p>19 THE WITNESS: I am not aware of</p> <p>20 what Mickey does in his lawyer work.</p> <p>21 QUESTIONS BY MR. FINCH:</p> <p>22 Q. Have you ever asked him what he</p> <p>23 does in his lawyer work, as you call it?</p> <p>24 A. No.</p> <p>25 Q. When you submit a paper to a</p>	<p>1 is doing to assess the credibility of that</p> <p>2 work?</p> <p>3 A. I don't really have an opinion</p> <p>4 on that. I've never thought about it, to be</p> <p>5 honest.</p> <p>6 Q. So it was not important to you</p> <p>7 in your collaborations with Mickey Gunther to</p> <p>8 ever ask him whether or not he has only and</p> <p>9 exclusively worked at the request of asbestos</p> <p>10 defendants in asbestos litigation?</p> <p>11 MR. FROST: Objection.</p> <p>12 QUESTIONS BY MR. FINCH:</p> <p>13 Q. It never crossed your mind to</p> <p>14 ask him that question?</p> <p>15 MR. CHACHKES: Objection.</p> <p>16 THE WITNESS: It never crossed</p> <p>17 my mind to ask him that question.</p> <p>18 QUESTIONS BY MR. FINCH:</p> <p>19 Q. I asked if you reviewed any</p> <p>20 internal Johnson & Johnson documents relating</p> <p>21 to the testing of the talc from its mines or</p> <p>22 in its finished products, and I believe your</p> <p>23 answer was, no, you never reviewed any of</p> <p>24 those documents; is that correct?</p> <p>25 A. No, sir.</p>
Page 75	Page 77
<p>1 peer-review journal, isn't it correct that</p> <p>2 oftentimes the authors are asked if they have</p> <p>3 any potential conflicts of interest that may</p> <p>4 bias or affect their views of the material in</p> <p>5 which they publish?</p> <p>6 A. That's something that's started</p> <p>7 happening in the last few years, yes.</p> <p>8 Q. And why -- in your</p> <p>9 understanding, why has that started happening</p> <p>10 in the past few years?</p> <p>11 MR. LOCKE: Objection.</p> <p>12 THE WITNESS: I never thought</p> <p>13 about it.</p> <p>14 QUESTIONS BY MR. FINCH:</p> <p>15 Q. Do you think it has anything to</p> <p>16 do with the fact that the readers of the</p> <p>17 paper are entitled to know whether the</p> <p>18 authors of the paper have any financial</p> <p>19 interest in the subject matter on which they</p> <p>20 are writing about?</p> <p>21 A. I've never thought about it. I</p> <p>22 don't know.</p> <p>23 Q. Do you think it's important to</p> <p>24 know whether or not a scientist has a</p> <p>25 financial interest in the work that he or she</p>	<p>1 Q. Have you ever reviewed any</p> <p>2 documents relating to anyone else's testing</p> <p>3 of the talc in Johnson & Johnson's mines or</p> <p>4 the finished product, other than Longo and</p> <p>5 Rigler?</p> <p>6 A. No, although I did recall over</p> <p>7 the break that I reviewed some additional</p> <p>8 reports of Drs. Longo and Rigler that didn't</p> <p>9 have any numbers on them. So I reviewed them</p> <p>10 briefly and then set them aside, so those are</p> <p>11 cited in my report.</p> <p>12 But in terms of your current</p> <p>13 question, no other reports.</p> <p>14 Q. Okay. So the only people who</p> <p>15 have tested Johnson & Johnson baby powder or</p> <p>16 samples of talc from the mines where the talc</p> <p>17 came from for the baby powder, the only</p> <p>18 people that you reviewed the work of are</p> <p>19 Longo and Rigler; is that correct?</p> <p>20 MR. FROST: Objection.</p> <p>21 THE WITNESS: I was hired to</p> <p>22 review the methodology of Longo and</p> <p>23 Rigler, so that's what I did, yes.</p> <p>24 QUESTIONS BY MR. FINCH:</p> <p>25 Q. Did you think it was at all</p>

Melinda Darby Dyar, Ph.D.

Page 78	Page 80
<p>1 important in analyzing the work of Longo and</p> <p>2 Rigler to compare their results and</p> <p>3 conclusions to what other scientists may have</p> <p>4 found when they've analyzed the same</p> <p>5 material -- or material from the same places?</p> <p>6 MR. FROST: Objection.</p> <p>7 THE WITNESS: No, it was not</p> <p>8 important because I am very familiar</p> <p>9 with the methodology that they use.</p> <p>10 And there was really no need to look</p> <p>11 and see what other people's work said</p> <p>12 because that had nothing to do with my</p> <p>13 review of the methodology.</p> <p>14 QUESTIONS BY MR. FINCH:</p> <p>15 Q. What is your definition of</p> <p>16 asbestos?</p> <p>17 A. My definition of asbestos is</p> <p>18 given in my report. If we can turn to</p> <p>19 page -- let's see, page 10. Asbestos is</p> <p>20 defined as one of six particular minerals</p> <p>21 exhibiting the characteristics of an</p> <p>22 asbestiform habit, meaning that they can be</p> <p>23 separated into flexible fibers with high</p> <p>24 tensile strength.</p> <p>25 And, of course, those six</p>	<p>1 Q. Have you ever done that?</p> <p>2 A. I have certainly looked at the</p> <p>3 tensile strength of mineral fibers. Not with</p> <p>4 a TEM, however.</p> <p>5 Q. How would you measure the</p> <p>6 flexibility -- is there any -- is there any</p> <p>7 peer-reviewed literature that you would rely</p> <p>8 on or that you could cite me to that</p> <p>9 describes how you would measure the tensile</p> <p>10 strength of a fiber that is 10 microns long</p> <p>11 or less?</p> <p>12 A. I did not consider that because</p> <p>13 that was not a method that was used by</p> <p>14 Drs. Longo and Rigler. Given sufficient time</p> <p>15 to research that topic, I'd be happy to give</p> <p>16 you an answer.</p> <p>17 Q. As you sit here today, you</p> <p>18 can't think of any literature that lays out a</p> <p>19 methodology to test the tensile strength of a</p> <p>20 fiber that is 10 microns or less?</p> <p>21 MR. FROST: Objection.</p> <p>22 THE WITNESS: I would have to</p> <p>23 do background research to answer that</p> <p>24 question.</p> <p>25</p>
Page 79	Page 81
<p>1 minerals are the ones given in the table and</p> <p>2 in other places in the report, anthophyllite,</p> <p>3 chrysotile, grunerite, tremolite, actinolite</p> <p>4 and riebeckite.</p> <p>5 Q. What is -- in your view qualify</p> <p>6 a fiber as having the morphology that is</p> <p>7 consistent with an asbestos fiber?</p> <p>8 A. So again, my definition of a</p> <p>9 fiber is given in the numerous literature</p> <p>10 citations on page 10 and 11, which</p> <p>11 consistently define fibers as being strong</p> <p>12 and flexible and having high tensile</p> <p>13 strength, including those in the ISO 22262,</p> <p>14 which define asbestiform in an identical way</p> <p>15 as a specific type of mineral fibrosity in</p> <p>16 which the fibers and fibrils possess high</p> <p>17 tensile strength and flexibility.</p> <p>18 Q. Is it possible to measure the</p> <p>19 tensile strength of a fiber that's 10 microns</p> <p>20 long?</p> <p>21 A. It is possible to constrain it</p> <p>22 with a probe, yes.</p> <p>23 Q. How would you do that?</p> <p>24 A. You would poke the fiber and</p> <p>25 see if it could bend.</p>	<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. Have you ever mentioned -- ever</p> <p>3 measured the tensile strength of asbestos?</p> <p>4 A. Not personally, no.</p> <p>5 Q. What is the unit of measurement</p> <p>6 that that -- that one would use to measure</p> <p>7 the tensile strength of asbestos?</p> <p>8 A. I don't know, and I did not</p> <p>9 consider that because a measurement of</p> <p>10 tensile strength was not part of the</p> <p>11 methodology of Drs. Longo and Rigler and,</p> <p>12 therefore, it wasn't considered by me in</p> <p>13 preparing this report.</p> <p>14 Q. Do you know what a pascal joule</p> <p>15 is?</p> <p>16 A. Yes.</p> <p>17 Q. What is it?</p> <p>18 A. It's a unit of force.</p> <p>19 Q. It's a unit of force that is</p> <p>20 one way to measure -- it's a measurement that</p> <p>21 you can calculate or determine the tensile</p> <p>22 strength of a material, correct?</p> <p>23 A. I'd have to research that to</p> <p>24 make sure I -- I agree with you. I have no</p> <p>25 knowledge of the exact methodology for</p>

21 (Pages 78 to 81)

Melinda Darby Dyar, Ph.D.

Page 82	Page 84
<p>1 measuring tensile strength but could easily</p> <p>2 understand that with a brief survey of the</p> <p>3 literature.</p> <p>4 Q. Pounds per square inch is</p> <p>5 another way to measure tensile strength?</p> <p>6 A. Certainly.</p> <p>7 Q. What dimensions does a particle</p> <p>8 need to have in order for it to be</p> <p>9 potentially characterized as an asbestos</p> <p>10 fiber?</p> <p>11 MR. FROST: Objection.</p> <p>12 THE WITNESS: So the answer to</p> <p>13 that question refers -- or depends on</p> <p>14 which guidelines you're looking at.</p> <p>15 QUESTIONS BY MR. FINCH:</p> <p>16 Q. In your view. In your opinion.</p> <p>17 A. I have no personal opinion in</p> <p>18 this matter. I just know what the different</p> <p>19 documents can tell you.</p> <p>20 Q. So you have no opinion as to</p> <p>21 what aspect ratio must be present in order</p> <p>22 for something to be characterized as having</p> <p>23 morphology that is consistent with asbestos?</p> <p>24 MR. LOCKE: Objection.</p> <p>25 Misstates testimony.</p>	<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. Yes.</p> <p>3 A. So as I said in my report, EDS</p> <p>4 and EDXA do not let -- do not have sufficient</p> <p>5 quantitative accuracy to allow discrimination</p> <p>6 between potentially asbestiform and</p> <p>7 non-asbestiform mineral species, many of</p> <p>8 which have very similar compositions, as</p> <p>9 given in Table 1 in my report.</p> <p>10 Q. Do you agree with me that</p> <p>11 information from an EDS, EDXA chemical</p> <p>12 signature can be useful to determine whether</p> <p>13 or not a given structure is asbestos or not</p> <p>14 if used in connection with other tools?</p> <p>15 MR. FROST: Objection.</p> <p>16 THE WITNESS: I believe that</p> <p>17 EDS can be used to determine the</p> <p>18 presence or absence of specific</p> <p>19 elements, but it cannot be used to</p> <p>20 make quantitative judgments on the</p> <p>21 ratios of the concentrations of those</p> <p>22 elements.</p> <p>23 That's not only my opinion but</p> <p>24 the opinion of Newbury and Ritchie and</p> <p>25 the National Institute of Standards</p>
Page 83	Page 85
<p>1 MR. FROST: Objection.</p> <p>2 MR. CHACHKES: Objection.</p> <p>3 THE WITNESS: My assessment of</p> <p>4 the literature suggests that aspect</p> <p>5 ratio is best understood in the</p> <p>6 context of a population, and the</p> <p>7 papers by Ann Wylie and others that I</p> <p>8 reference in my report talk about</p> <p>9 amphibole populations.</p> <p>10 And so my personal opinion is</p> <p>11 that analysis of populations is the</p> <p>12 optimal way to understand asbestos,</p> <p>13 but that is -- that is the preliminary</p> <p>14 opinion, and I'd want to think about</p> <p>15 it and do some research on it.</p> <p>16 My personal opinion did not</p> <p>17 come up in this particular report.</p> <p>18 QUESTIONS BY MR. FINCH:</p> <p>19 Q. In order for a structure to</p> <p>20 meet your definition of asbestos, what does</p> <p>21 the EDS or EDXA chemical signature have to</p> <p>22 be?</p> <p>23 MR. FROST: Objection.</p> <p>24 THE WITNESS: You said EDS and</p> <p>25 EDXA chemical signature have to be?</p>	<p>1 and Technology and numerous other</p> <p>2 scientists.</p> <p>3 QUESTIONS BY MR. FINCH:</p> <p>4 Q. Do you agree that SAED is a</p> <p>5 useful tool to determine whether or not a</p> <p>6 particle or structure has a crystalline</p> <p>7 structure that when used in conjunction with</p> <p>8 other tools allows you to determine whether</p> <p>9 or not it's asbestos or not?</p> <p>10 A. SAED is a tool that allows you</p> <p>11 to determine what the crystal structure of</p> <p>12 the particle is. You would need other</p> <p>13 information to determine whether the particle</p> <p>14 was asbestos.</p> <p>15 Q. How would you measure the</p> <p>16 flexibility of an asbestos fiber that is</p> <p>17 10 microns or less in length?</p> <p>18 MR. FROST: Objection. Asked</p> <p>19 and answered.</p> <p>20 MR. FINCH: No, I asked about</p> <p>21 tensile strength.</p> <p>22 THE WITNESS: So I would</p> <p>23 imagine that you would use a probe,</p> <p>24 but I would have to do some more</p> <p>25 research. And I can certainly do</p>

Melinda Darby Dyar, Ph.D.

Page 86	Page 88
<p>1 that, but not -- I don't have an</p> <p>2 opinion on that at the present time.</p> <p>3 QUESTIONS BY MR. FINCH:</p> <p>4 Q. You've never used a probe to</p> <p>5 determine the flexibility of an asbestos</p> <p>6 fiber under a microscope?</p> <p>7 A. No, that has never been</p> <p>8 necessary in my research. I've analyzed many</p> <p>9 amphiboles and certainly many minerals that</p> <p>10 are asbestos, but it was apparent</p> <p>11 microscopically that those phases were</p> <p>12 asbestos -- or they were identified to me as</p> <p>13 such, so that I had no need to verify them by</p> <p>14 testing their flexibility.</p> <p>15 Q. And so am I correct that ISO</p> <p>16 22262-1 and ISO 22262-2 don't set forth any</p> <p>17 steps or methodologies that a scientist or</p> <p>18 analyst should follow to determine either the</p> <p>19 tensile strength or the flexibility of a</p> <p>20 fiber that is being analyzed under either of</p> <p>21 those protocols?</p> <p>22 A. You know, I'd have to go back</p> <p>23 and re-read them with that question in mind.</p> <p>24 I would be happy to take the time to do that.</p> <p>25 I don't recall.</p>	<p>1 Vermont?</p> <p>2 A. No. None.</p> <p>3 Q. So you don't have any</p> <p>4 understanding as to whether the talc in</p> <p>5 Vermont came from the Hammondsville mine, the</p> <p>6 Hamm mine, the Rainbow mine or the Argonaut</p> <p>7 mine?</p> <p>8 MR. FROST: Objection.</p> <p>9 THE WITNESS: Or anywhere else,</p> <p>10 no.</p> <p>11 (Dyar Exhibit 8 marked for</p> <p>12 identification.)</p> <p>13 QUESTIONS BY MR. FINCH:</p> <p>14 Q. Let's mark this as Exhibit 8.</p> <p>15 This is Dr. Longo's second</p> <p>16 supplemental report, which is dated</p> <p>17 February 1, 2019.</p> <p>18 Professor Dyar, Darby Dyar,</p> <p>19 have you seen -- you've obviously reviewed</p> <p>20 Dr. Longo's report in the backup materials</p> <p>21 dated January 16th, correct?</p> <p>22 A. Yes, I've typed all these</p> <p>23 numbers into a spreadsheet.</p> <p>24 Q. Okay. And did you also review</p> <p>25 the February 1st report which contained a</p>
Page 87	Page 89
<p>1 Q. You don't know whether they do</p> <p>2 or not as you sit here today?</p> <p>3 A. I don't recall.</p> <p>4 Q. What is your understanding of</p> <p>5 what mines Johnson & Johnson got its talc</p> <p>6 from?</p> <p>7 MR. FROST: Objection.</p> <p>8 THE WITNESS: All I know is</p> <p>9 that they came from China -- hang on,</p> <p>10 let me find my figure -- and Vermont</p> <p>11 and another place, which I don't</p> <p>12 recall.</p> <p>13 QUESTIONS BY MR. FINCH:</p> <p>14 Q. Do you have the chronology as</p> <p>15 to when Johnson & Johnson got its talc from</p> <p>16 Vermont versus when it got its talc from</p> <p>17 China versus when it got its talc from Italy?</p> <p>18 A. Yes, I believe those data are</p> <p>19 noted in my spreadsheet, and I believe that</p> <p>20 the data themselves are in the Longo and</p> <p>21 Rigler reports. I can't recall exactly where</p> <p>22 they came from.</p> <p>23 Q. Do you have an understanding of</p> <p>24 how many different mines Johnson & Johnson</p> <p>25 got talc from that went into baby powder from</p>	<p>1 couple of corrections to his earlier report?</p> <p>2 A. I believe so, yes.</p> <p>3 Q. Okay. I'm going to use -- I'm</p> <p>4 not going to mark the entire 2,000-page</p> <p>5 January report as an exhibit to save trees.</p> <p>6 I think we all know that's the report that</p> <p>7 you were looking at when you wrote your</p> <p>8 expert witness report, correct?</p> <p>9 A. One of the reports, yes.</p> <p>10 Q. On page 8 of Dr. Longo's</p> <p>11 report, which we've marked as Darby Dyar 8 --</p> <p>12 let me know when you're there.</p> <p>13 A. I'm there.</p> <p>14 Q. Under ATEM, four pages down --</p> <p>15 four paragraphs down, Drs. Longo and Rigler</p> <p>16 state, "Two different regulated amphibole</p> <p>17 asbestos types were found. These were the</p> <p>18 tremolite asbestos solid solution series</p> <p>19 amphiboles, which includes tremolite,</p> <p>20 winchite, richterite and actinolite, and the</p> <p>21 anthophyllite asbestos solid solution series</p> <p>22 that includes anthophyllite, iron-rich</p> <p>23 anthophyllite, ferro-anthophyllite,</p> <p>24 cummingtonite and grunerite."</p> <p>25 Do you see that?</p>

23 (Pages 86 to 89)

Melinda Darby Dyar, Ph.D.

Page 90	Page 92
<p>1 A. I see that that's what the 2 report says, yes. 3 Q. Okay. What is the 4 anthophyllite asbestos solid solution series? 5 A. So if you return to my 6 document, Table 1 has a handy table with 7 those mineral formulas in it. 8 So if you look at the formula 9 of anthophyllite, which is $Mg_7(Si_8O_{22})(OH)_2$, 10 you see it's a solid solution with some other 11 amphiboles in this list that include iron, 12 such as grunerite. 13 Q. And what does that mean? 14 A. It means that there can be a 15 continuous range of chemical substitution 16 between those two end numbers. 17 Q. And do you know whether all the 18 materials in the anthophyllite asbestos solid 19 solution series are treated as regulated 20 asbestos or not? 21 MR. FROST: Objection. Form. 22 THE WITNESS: I know that the 23 six stated regulated amphibole 24 asbestos species are the ones given in 25 my report.</p>	<p>1 cummingtonite and grunerite, correct? 2 A. I'd have to look up -- look 3 that up. I'm sure that the amphibole 4 chemistries are so complicated -- as you will 5 recall from my report, there are some 80-odd 6 amphibole species with solid solutions 7 intermixed among them. 8 So, yes, these species are all 9 related, but so are many other amphibole 10 species as well. 11 Q. Are you familiar with Klein and 12 Hurlbut's Manual of Mineralogy? 13 A. Yes. 14 Q. What is that? 15 A. It's a very old mineralogy 16 textbook. 17 (Dyar Exhibit 9 marked for 18 identification.) 19 QUESTIONS BY MR. FINCH: 20 Q. Let's mark this as Exhibit 9. 21 On page 489 of Exhibit 9, there 22 is a diagram there. 23 MR. FINCH: And can I have the 24 Elmo -- 25 VIDEOGRAPHER: Sure.</p>
Page 91	Page 93
<p>1 QUESTIONS BY MR. FINCH: 2 Q. My question was a little 3 different. 4 Do you know if the -- all of 5 the materials in the anthophyllite asbestos 6 solid solution series are treated as 7 regulated asbestos? 8 MR. FROST: Objection. 9 MR. CHACHKES: Objection. 10 THE WITNESS: I'm telling you 11 that what I know is that the regulated 12 asbestos species are the ones given in 13 my report. 14 QUESTIONS BY MR. FINCH: 15 Q. One of which is anthophyllite, 16 correct? 17 A. Yes, as IARC 2012 identifies 18 them, the five amphibole minerals: 19 actinolite, amosite, anthophyllite, 20 crocidolite and tremolite. 21 Q. Okay. My question is a little 22 bit different. 23 The anthophyllite asbestos 24 solid solution series includes anthophyllite, 25 iron-rich anthophyllite, ferro-anthophyllite,</p>	<p>1 MR. FINCH: -- so people who 2 are not privy to the document can see 3 what I'm talking about? 4 THE WITNESS: So what year was 5 this particular edition of Hurlbut and 6 Klein published? 7 MR. FINCH: Sometime in the 8 1980s, I believe, but -- 9 THE WITNESS: So this would not 10 include the revision of amphibole 11 nomenclature that was approved by the 12 International Mineralogical Society, 13 or association, I don't know, sometime 14 in the '80s by Hawthorne, et al., in 15 which the amphibole nomenclature was 16 extensively rewritten. So this 17 definition in these documents are 18 significantly out of date. 19 QUESTIONS BY MR. FINCH: 20 Q. Okay. My question is: Do you 21 know whether or not cummingtonite, 22 ferro-anthophyllite, iron-rich anthophyllite 23 and grunerite are treated as regulated 24 asbestos by the United States EPA, OSHA or 25 any other governmental organization?</p>

24 (Pages 90 to 93)

Melinda Darby Dyar, Ph.D.

Page 94	Page 96
<p>1 MR. CHACHKES: Objection.</p> <p>2 MR. FROST: Objection.</p> <p>3 THE WITNESS: I am only aware</p> <p>4 of these six amphibole species given</p> <p>5 in my report to be regulated asbestos</p> <p>6 minerals.</p> <p>7 QUESTIONS BY MR. FINCH:</p> <p>8 Q. Do you agree that iron-rich</p> <p>9 anthophyllite is found in the anthophyllite</p> <p>10 asbestos solid solution series?</p> <p>11 A. If indeed that is still the</p> <p>12 name of the mineral species -- I'm inferring</p> <p>13 what you mean by that -- I would say that</p> <p>14 possibly it would be part of the solid</p> <p>15 solution series.</p> <p>16 Q. Am I correct that cummingtonite</p> <p>17 and anthophyllite have the same chemical</p> <p>18 structure?</p> <p>19 A. All amphiboles have the same</p> <p>20 chemical structure in many ways. There are</p> <p>21 slight deviations depending on the</p> <p>22 composition.</p> <p>23 Q. All right.</p> <p>24 A. So just as all the other end</p> <p>25 amphibole minerals in the amphibole group</p>	<p>1 MR. CHACHKES: Objection.</p> <p>2 MR. FROST: Objection.</p> <p>3 THE WITNESS: My goal in</p> <p>4 reviewing this report was to examine</p> <p>5 the methodology. My goal was not to</p> <p>6 opine on amphibole regulations.</p> <p>7 QUESTIONS BY MR. FINCH:</p> <p>8 Q. I take it you have no opinion</p> <p>9 as to whether cummingtonite can cause</p> <p>10 mesothelioma or ovarian cancer if it's</p> <p>11 inhaled?</p> <p>12 MR. FROST: Objection.</p> <p>13 THE WITNESS: I have no</p> <p>14 opinion.</p> <p>15 QUESTIONS BY MR. FINCH:</p> <p>16 Q. Would you agree with me that --</p> <p>17 let me back up.</p> <p>18 Do you know what accessory</p> <p>19 minerals were found in talc from the Vermont</p> <p>20 mines from which Johnson & Johnson obtained</p> <p>21 the talc for its baby powder?</p> <p>22 MR. FROST: Objection to form.</p> <p>23 THE WITNESS: No, I have no</p> <p>24 idea.</p> <p>25</p>
Page 95	Page 97
<p>1 have the same structure, yes, they have the</p> <p>2 same structure.</p> <p>3 Q. Okay. Looking at Table 1 on</p> <p>4 page 9 of your report, am I correct that</p> <p>5 anthophyllite and cummingtonite have the</p> <p>6 exact same chemical makeup in terms of the</p> <p>7 chemical formula?</p> <p>8 A. That is correct.</p> <p>9 Q. All right. Do you know whether</p> <p>10 cummingtonite is treated as regulated</p> <p>11 asbestos by any governmental or international</p> <p>12 organization?</p> <p>13 MR. CHACHKES: Objection.</p> <p>14 THE WITNESS: I am aware only</p> <p>15 of the six regulated amphibole -- or</p> <p>16 six regulated asbestos -- potential</p> <p>17 asbestiform minerals that are given in</p> <p>18 my report.</p> <p>19 QUESTIONS BY MR. FINCH:</p> <p>20 Q. So is the answer to my</p> <p>21 question, no, you don't know one way or the</p> <p>22 other whether cummingtonite is treated as a</p> <p>23 subset of anthophyllite for regulatory</p> <p>24 purposes?</p> <p>25 MR. LOCKE: Objection.</p>	<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. Do you know what accessory</p> <p>3 minerals are typically found in talc mines?</p> <p>4 MR. FROST: Objection. Form.</p> <p>5 THE WITNESS: No, I have no</p> <p>6 idea. I am familiar in the general</p> <p>7 sense with the rock types, metamorphic</p> <p>8 rock types, in which talc occurs. I</p> <p>9 know it's a low-grade metamorphic</p> <p>10 mineral, but that's -- I know nothing</p> <p>11 specifically about Vermont.</p> <p>12 QUESTIONS BY MR. FINCH:</p> <p>13 Q. Can talc be contaminated with</p> <p>14 asbestos?</p> <p>15 MR. FROST: Objection to form.</p> <p>16 THE WITNESS: I have no opinion</p> <p>17 on that. I'd have to research that</p> <p>18 question.</p> <p>19 QUESTIONS BY MR. FINCH:</p> <p>20 Q. From what parts of the world</p> <p>21 has talc been found to be contaminated with</p> <p>22 asbestos?</p> <p>23 MR. FROST: Objection.</p> <p>24 THE WITNESS: Based on the</p> <p>25 information in my report and the</p>

25 (Pages 94 to 97)

Melinda Darby Dyar, Ph.D.

Page 98	Page 100
<p>1 samples tested by Drs. Longo and 2 Rigler, there is no evidence to 3 suggest that any samples tested by 4 Drs. Longo and Rigler are contaminated 5 with asbestos. 6 QUESTIONS BY MR. FINCH: 7 Q. That's not my question. 8 From what parts of the world 9 has talc been found to be contaminated with 10 asbestos, as discussed in either the 11 peer-reviewed literature or in publications 12 by entities such as IARC? 13 MR. LOCKE: Objection. 14 MR. FROST: Objection. 15 THE WITNESS: I have no 16 knowledge of that because I was not 17 asked to review talc paragenesis. I 18 was asked to review methodology only. 19 QUESTIONS BY MR. FINCH: 20 Q. You mentioned IARC in response 21 to one of my questions a few minutes ago. 22 What is that? 23 A. It's yet another international 24 standard report. I'd have to take a look at 25 that report to give you a more specific</p>	<p>1 mined in Vermont. 2 Q. Do you have -- do you agree or 3 disagree that talc mines in Vermont have been 4 found to contain asbestos? 5 MR. FROST: Objection. 6 MR. LOCKE: Objection. 7 THE WITNESS: Based on my 8 reading of the data in Drs. Longo and 9 Rigler's reports, there is no evidence 10 to suggest that there is any asbestos 11 in any of the talcum powder samples 12 they studied, some of which I 13 understand are from Vermont. 14 QUESTIONS BY MR. FINCH: 15 Q. Do you agree or disagree that 16 talc mines in Vermont owned by Johnson & 17 Johnson or its subsidiary, Windsor Minerals, 18 have been tested and found to contain trace 19 amounts of asbestos? 20 MR. CHACHKES: Objection. 21 THE WITNESS: I have no 22 knowledge of that. Please support 23 your supposition. 24 (Dyar Exhibit 10 marked for 25 identification.)</p>
Page 99	Page 101
<p>1 answer. 2 Q. Do you understand that IARC is 3 the International Agency for Research on 4 Cancer? 5 A. I had no idea that's what it 6 stood for. I don't recall that from when I 7 reviewed the report. 8 Q. Were you aware that IARC 9 concluded that talc contaminated with 10 asbestiform fibers can cause mesothelioma and 11 other asbestos-related cancers? 12 MR. FROST: Objection to form. 13 THE WITNESS: I'm not aware of 14 that. If it was in the report, I 15 don't recall it. I was specifically 16 reading the report for relevance to my 17 methodology inquiries. 18 QUESTIONS BY MR. FINCH: 19 Q. Do you agree or disagree that 20 asbestos was mined in Vermont? 21 A. Assuming that the information 22 that was given to me was correct, then I 23 think some of the talcum powder samples that 24 I studied were mined in Vermont, but I have 25 no knowledge of whether asbestos was found or</p>	<p>1 QUESTIONS BY MR. FINCH: 2 Q. Professor Darby Dyar, have -- 3 you've seen this publication before, correct? 4 A. I have seen this paper, yes. I 5 believe I cited it, 1991, yes. 6 Q. When did you first review this 7 publication? 8 A. For the purposes of assessing 9 the so-called Blount method cited by 10 Dr. Longo. 11 Q. All right. The title of the 12 paper is "Amphibole Content of Cosmetic and 13 Pharmaceutical Talcs"? 14 A. That is correct. That is the 15 title. 16 Q. And this was published in a 17 peer-reviewed journal and describes a 18 methodology for preparing talc in order to 19 analyze whether or not there's asbestos 20 fibers or asbestos bundles in it, correct? 21 A. Its goal is to determine the 22 number of amphibole particles in a sample, 23 yes. 24 Q. And the author analyzes various 25 samples of talc under PLM, correct?</p>

26 (Pages 98 to 101)

Melinda Darby Dyar, Ph.D.

Page 102	Page 104
<p>1 A. So give me a few minutes, and 2 I'll take a look at this paper and refresh my 3 memory so I can answer your question. 4 So in this case, these samples 5 are being analyzed on a microscope slide, 6 which implies that in fact he is using 7 polarized light microscopy, yes, although in 8 point of fact he doesn't state that. 9 Q. You mean that it's Alice 10 Blount. She -- 11 A. Well, she does not state that. 12 Sorry, Alice. 13 Q. Are you aware of the origin of 14 the samples that Professor Blount was 15 testing? 16 A. It says five deposits in 17 Montana, three in Vermont, and one each in 18 North Carolina and Alabama. 19 Q. And also finished products, 20 correct? 21 A. That's what it says here: In 22 addition, four talcs from outside the US but 23 available on the US market were included in 24 this study. 25 Q. Have you reviewed Dr. Blount's</p>	<p>1 QUESTIONS BY MR. FINCH: 2 Q. Okay. You don't offer any 3 criticisms of either the chain of custody or 4 the conclusion that what he was, in fact, 5 analyzing was talc that came from either 6 Johnson & Johnson finished products or the 7 mines from which Johnson & Johnson finished 8 products were made? 9 MR. FROST: Objection. 10 THE WITNESS: I would say that 11 it is unclear to me whether the 12 samples he got were from eBay, whether 13 they had been opened, whether they had 14 been contaminated, so it's unclear to 15 me exactly what he was testing. 16 I know what he asserts in his 17 report, but I -- it's unclear to me 18 that he was testing unopened, pure, 19 pristine talc as marketed. 20 QUESTIONS BY MR. FINCH: 21 Q. Were you aware that there was a 22 procedure in this MDL for samples to be split 23 between Johnson & Johnson and Dr. Longo from 24 historical museum samples that Johnson & 25 Johnson had maintained?</p>
Page 103	Page 105
<p>1 deposition taken in connection with ovarian 2 cancer litigation? 3 A. No. 4 Q. Have you reviewed Dr. Blount's 5 correspondence with Johnson & Johnson where 6 she tells Johnson & Johnson she identified 7 asbestos fibers in baby powder? 8 MR. FROST: Objection. 9 THE WITNESS: No, I have not 10 reviewed such a document. 11 QUESTIONS BY MR. FINCH: 12 Q. Dr. Longo -- let me see if you 13 agree with this description of generally the 14 various steps that Dr. Longo and his lab 15 followed to analyze the samples of talc he 16 obtained from Johnson & Johnson or Imerys. 17 First of all, he got samples of 18 talc from either Johnson & Johnson or Imerys. 19 Do you have that understanding? 20 MR. CHACHKES: Objection. 21 THE WITNESS: I honestly don't 22 recall where he said he got them. I 23 recall seeing a chain-of-custody 24 paperwork. I wasn't paying attention 25 to where he got the samples from.</p>	<p>1 MR. FROST: Objection. 2 THE WITNESS: Yes, certainly 3 one of the documents is called 4 historical samples, so I'm aware that 5 the samples came from the museum and, 6 therefore, are unknown sources in 7 terms of being opened or being pure. 8 QUESTIONS BY MR. FINCH: 9 Q. But you don't criticize or take 10 issue with Dr. Longo's conclusions that what, 11 in fact, he is testing is talc that came from 12 Johnson & Johnson finished products or 13 Johnson & Johnson mines, correct? 14 MR. CHACHKES: Objection. 15 MR. FROST: Objection. 16 THE WITNESS: I do indeed have 17 problems with that statement because 18 you don't know if those samples, 19 having been stored in a museum or in 20 someone's cupboard, were opened and 21 exposed to contamination. So I don't 22 know that. 23 QUESTIONS BY MR. FINCH: 24 Q. Well, you certainly didn't 25 comment upon it in your report, correct?</p>

27 (Pages 102 to 105)

Melinda Darby Dyar, Ph.D.

Page 106	Page 108
<p>1 A. It wasn't relevant to my</p> <p>2 question of whether the methodology that he</p> <p>3 used to analyze the samples was appropriate</p> <p>4 or not.</p> <p>5 Q. All right. So he got the</p> <p>6 samples from Johnson & Johnson in this</p> <p>7 litigation, the samples that are analyzed in</p> <p>8 his February 1, 2019 report. And then for</p> <p>9 many of the samples, he used what is called</p> <p>10 the Blount preparation method, correct?</p> <p>11 A. That is correct.</p> <p>12 Q. All right. I read through your</p> <p>13 report, and I didn't see any criticisms</p> <p>14 related to the way in which he applied the</p> <p>15 Blount preparation method to prepare the</p> <p>16 samples for analysis; is that correct?</p> <p>17 MR. LOCKE: Objection.</p> <p>18 THE WITNESS: Correct, there is</p> <p>19 nothing in my report that criticizes</p> <p>20 his use of the Blount method.</p> <p>21 QUESTIONS BY MR. FINCH:</p> <p>22 Q. Do you agree that use of the</p> <p>23 Blount method to prepare a talc sample in</p> <p>24 order to analyze whether or not it's</p> <p>25 contaminated with asbestos is a reasonable</p>	<p>1 and talc out for purposes of analyzing</p> <p>2 whether or not they contain asbestos?</p> <p>3 A. It certainly contains something</p> <p>4 that indicate -- tells how to separate out</p> <p>5 things with different densities, and it talks</p> <p>6 specifically about asbestos.</p> <p>7 And I note that the refractive</p> <p>8 index, or the density, of the liquid that</p> <p>9 they say to use is different than the one</p> <p>10 used in the Blount paper. One is 1 point --</p> <p>11 I don't remember, but they're different.</p> <p>12 So Dr. Longo did not follow</p> <p>13 what's in the ISO report. He followed what's</p> <p>14 in the Blount report.</p> <p>15 Q. He reviewed what's in the</p> <p>16 Blount peer-reviewed paper, correct?</p> <p>17 A. He used the 1.610, I believe,</p> <p>18 density method.</p> <p>19 Q. Were you aware that the Blount</p> <p>20 paper was cited in the IARC publication you</p> <p>21 were referring to earlier relating to talc</p> <p>22 with asbestiform fibers?</p> <p>23 MR. FROST: Objection.</p> <p>24 THE WITNESS: I don't recall</p> <p>25 that.</p>
Page 107	Page 109
<p>1 and reliable thing for a scientist to do in</p> <p>2 testing talc for the presence of asbestos?</p> <p>3 A. I actually would say I do not</p> <p>4 agree with that. In fact, I do not agree</p> <p>5 with the results in the Blount paper.</p> <p>6 For example, Figure 1 in</p> <p>7 Blount's paper which -- or Figure 2, which</p> <p>8 purports to give the specific gravities of</p> <p>9 talc and amphibole, is just simply wrong.</p> <p>10 Those ranges are far wider and far more</p> <p>11 overlapping than she is apparently</p> <p>12 knowledgeable of.</p> <p>13 So in my mind, the simple fact</p> <p>14 that the densities of these minerals overlap</p> <p>15 each other a great degree renders the Blount</p> <p>16 method to be difficult to use, at best.</p> <p>17 Q. But you didn't, in your report,</p> <p>18 criticize Dr. Longo's use of the Blount</p> <p>19 method; is that correct?</p> <p>20 A. In my written report I did not</p> <p>21 state that criticism, no.</p> <p>22 Q. Okay. And am I correct that</p> <p>23 ISO 22262-2 describes a gravimetric --</p> <p>24 A. Gravimetric, yes.</p> <p>25 Q. -- method to separate materials</p>	<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. Do you agree with me that IARC</p> <p>3 generally only cites to reputable papers in</p> <p>4 its work?</p> <p>5 MR. FROST: Objection.</p> <p>6 MR. CHACHKES: Objection.</p> <p>7 THE WITNESS: I have no</p> <p>8 independent knowledge of IARC, so I</p> <p>9 can't really answer that question.</p> <p>10 QUESTIONS BY MR. FINCH:</p> <p>11 Q. Nonetheless, the Blount</p> <p>12 methodology as described in her paper was</p> <p>13 published in a peer-reviewed journal,</p> <p>14 correct?</p> <p>15 A. I've never encountered this</p> <p>16 journal before, but I'm assuming that if it's</p> <p>17 called a journal, it is indeed peer reviewed.</p> <p>18 But I'd have to corroborate that. I don't</p> <p>19 know anything about this journal. It's not a</p> <p>20 highly ranked journal.</p> <p>21 Q. What systematic study have you</p> <p>22 done to determine whether Environmental</p> <p>23 Health Perspectives is ranked highly or not</p> <p>24 ranked highly?</p> <p>25 MR. CHACHKES: Objection.</p>

Melinda Darby Dyar, Ph.D.

Page 110	Page 112
<p>1 THE WITNESS: It would be a</p> <p>2 simple matter to log on to the Web of</p> <p>3 Science and determine the rating of</p> <p>4 that journal, but I have not done</p> <p>5 that. I'm not in the habit of</p> <p>6 establishing the ratings on all the</p> <p>7 papers that I read.</p> <p>8 I am very familiar with the</p> <p>9 premier journals in the subject of</p> <p>10 mineralogy, and that's not one of</p> <p>11 them.</p> <p>12 QUESTIONS BY MR. FINCH:</p> <p>13 Q. Would you agree with me there</p> <p>14 are many different disciplines of science</p> <p>15 that bear on the question of what is</p> <p>16 asbestos?</p> <p>17 MR. FROST: Objection. Vague.</p> <p>18 MR. CHACHKES: Objection.</p> <p>19 THE WITNESS: No, I wouldn't</p> <p>20 agree with that.</p> <p>21 I would say that the definition</p> <p>22 of asbestos is fairly straightforward,</p> <p>23 as given in my report, and it is</p> <p>24 firmly grounded in both mineralogy and</p> <p>25 the other fields that are cited.</p>	<p>1 deposition.</p> <p>2 MR. CHACHKES: By the way,</p> <p>3 we've been going about an hour. Maybe</p> <p>4 at some point take a break.</p> <p>5 QUESTIONS BY MR. FINCH:</p> <p>6 Q. Do you agree or disagree that</p> <p>7 the most common asbestos mineral found as a</p> <p>8 contaminant of talc is tremolite asbestos?</p> <p>9 MR. FROST: Objection. Form.</p> <p>10 THE WITNESS: No, I do not</p> <p>11 agree with that. I have no knowledge</p> <p>12 of that. In fact, based on the Longo,</p> <p>13 Rigler reports, I have no evidence</p> <p>14 that suggests that any asbestos</p> <p>15 minerals are found in talc.</p> <p>16 QUESTIONS BY MR. FINCH:</p> <p>17 Q. Do you have an opinion one way</p> <p>18 or another as to whether talc can be</p> <p>19 contaminated with anthophyllite asbestos or</p> <p>20 tremolite asbestos when it is mined out of</p> <p>21 the ground?</p> <p>22 MR. LOCKE: Objection.</p> <p>23 THE WITNESS: I know nothing</p> <p>24 about mining practices. I'm not a</p> <p>25 mining geologist, so I have no opinion</p>
Page 111	Page 113
<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. At the end of page 230 in her</p> <p>3 paper, Dr. Blount writes that "In addition,</p> <p>4 the tendency to bring down a disproportionate</p> <p>5 number of larger particles has the advantage</p> <p>6 that with true asbestiform amphiboles one</p> <p>7 generally sees some particles showing bundles</p> <p>8 of fibrils, which removes any doubt about the</p> <p>9 nature of the amphibole."</p> <p>10 Do you see that?</p> <p>11 A. I see that the paper says that,</p> <p>12 yes.</p> <p>13 Q. Do you agree that if you find</p> <p>14 bundles of fibrils that are amphibole in</p> <p>15 nature, it makes it more likely than not that</p> <p>16 what you're looking at is asbestiform</p> <p>17 amphibole?</p> <p>18 A. No, I do not agree with that</p> <p>19 statement.</p> <p>20 Q. Why not?</p> <p>21 A. First of all, you'd need to</p> <p>22 define "bundle." And to my knowledge, the</p> <p>23 way asbestos is deformed -- defined does not</p> <p>24 include the term "bundle," as stated in the</p> <p>25 definition I've given previously in this</p>	<p>1 on that.</p> <p>2 QUESTIONS BY MR. FINCH:</p> <p>3 Q. You have no opinion about</p> <p>4 whether or not the -- you haven't reviewed</p> <p>5 all of the data that exists in the world as</p> <p>6 to testing done on Johnson's baby powder or</p> <p>7 the talc that went into Johnson's baby powder</p> <p>8 to determine whether or not it contained</p> <p>9 asbestos, correct?</p> <p>10 MR. LOCKE: Objection.</p> <p>11 MR. CHACHKES: Objection.</p> <p>12 THE WITNESS: My role here was</p> <p>13 to evaluate the methodology used by</p> <p>14 Drs. Longo and Rigler, so such an</p> <p>15 assertion would be far, far outside of</p> <p>16 what I researched and was asked to do.</p> <p>17 QUESTIONS BY MR. FINCH:</p> <p>18 Q. Okay. You are a geologist by</p> <p>19 training, correct?</p> <p>20 A. Correct.</p> <p>21 Q. As a matter of geology, do you</p> <p>22 agree with me that talc can be contaminated</p> <p>23 with accessory minerals, minerals that are</p> <p>24 not talc?</p> <p>25 A. Of course.</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 114</p> <p>1 Q. You agree with me --</p> <p>2 A. Metamorphic rocks that contain</p> <p>3 talc often have other minerals in them, yes.</p> <p>4 Q. You agree that talc can be</p> <p>5 contaminated with anthophyllite asbestos?</p> <p>6 MR. FROST: Objection.</p> <p>7 THE WITNESS: I have no</p> <p>8 specific knowledge of the assemblages</p> <p>9 that are stable with talc. I only</p> <p>10 know that it's a low-grade metamorphic</p> <p>11 mineral, but I know nothing about the</p> <p>12 other phases that are present. I'm</p> <p>13 not a metamorphic geologist.</p> <p>14 QUESTIONS BY MR. FINCH:</p> <p>15 Q. So you don't know one way or</p> <p>16 another whether or not talc can be</p> <p>17 contaminated with anthophyllite asbestos; is</p> <p>18 that fair?</p> <p>19 MR. LOCKE: Objection.</p> <p>20 THE WITNESS: I have no</p> <p>21 knowledge of the natural parageneses</p> <p>22 of talc, beyond the fact that it's a</p> <p>23 low-grade metamorphic mineral.</p> <p>24 QUESTIONS BY MR. FINCH:</p> <p>25 Q. Do you agree or disagree with</p>	<p style="text-align: right;">Page 116</p> <p>1 which determines in part whether it's</p> <p>2 monoclinic or orthorhombic. And I would also</p> <p>3 use polarized light microscopy on multiple</p> <p>4 grains to determine the -- in part the</p> <p>5 chemistry of the particle. And then I would</p> <p>6 sample populations of particles to determine</p> <p>7 them in an ideal sense.</p> <p>8 But this would be only</p> <p>9 something I would do in the laboratory, in</p> <p>10 the sort of -- in a careful study with my</p> <p>11 students.</p> <p>12 Q. Okay. So you would -- you</p> <p>13 mentioned you would use multiple zone axis</p> <p>14 analysis.</p> <p>15 You're talking about SAED,</p> <p>16 correct?</p> <p>17 A. Correct.</p> <p>18 Q. So you would use -- one tool</p> <p>19 you would use is an electron microscope,</p> <p>20 correct?</p> <p>21 A. Uh-huh. Yes.</p> <p>22 Q. Then you would do EDS, EDXA, to</p> <p>23 determine the chemistry, the elemental</p> <p>24 chemistry, of a material, correct?</p> <p>25 A. I would use it to determine</p>
<p style="text-align: right;">Page 115</p> <p>1 the fact that talc can be contaminated with</p> <p>2 anthophyllite asbestos or tremolite asbestos?</p> <p>3 MR. CHACHKES: Objection.</p> <p>4 THE WITNESS: I disagree with</p> <p>5 that. I don't know that that's a</p> <p>6 fact, and I have not researched that</p> <p>7 personally, so I have no opinion on</p> <p>8 it. But I do not certainly consider</p> <p>9 it a fact.</p> <p>10 QUESTIONS BY MR. FINCH:</p> <p>11 Q. What tools would you use to</p> <p>12 test a sample of talc to determine if it</p> <p>13 contains asbestos?</p> <p>14 A. Again, I was not asked to rule</p> <p>15 on that, but if I were to do testing, I would</p> <p>16 probably follow some combination of the Su</p> <p>17 protocols and those articulated in the Yamate</p> <p>18 document, which was exhibit whatever.</p> <p>19 Q. What are the tools that you</p> <p>20 would use?</p> <p>21 I'm not asking about the</p> <p>22 protocols you would follow. What tools?</p> <p>23 A. I would ideally use multiple</p> <p>24 zone axis determinations combined with EDS to</p> <p>25 rule out or confirm the presence of calcium,</p>	<p style="text-align: right;">Page 117</p> <p>1 whether or not calcium was present, yes.</p> <p>2 Q. All right. And that is, again,</p> <p>3 using a transmission electron microscope,</p> <p>4 correct?</p> <p>5 A. Or an SEM, yes.</p> <p>6 Q. And does it matter in which</p> <p>7 order that you would do steps 1 and 2,</p> <p>8 meaning would you first -- does it matter</p> <p>9 whether you first analyze it using EDS, EDXA,</p> <p>10 or whether you first analyze it using SAED?</p> <p>11 A. I would think it would not --</p> <p>12 it certainly doesn't matter.</p> <p>13 Q. The third step, you said, would</p> <p>14 be to analyze it using a polarized light</p> <p>15 microscope, correct?</p> <p>16 A. Yes.</p> <p>17 Q. Does it matter in which order</p> <p>18 you would analyze it using a polarized light</p> <p>19 microscope?</p> <p>20 Meaning would you do SAED or an</p> <p>21 EDS before or after the PLM, or does it not</p> <p>22 matter?</p> <p>23 A. Well, you presumably wouldn't</p> <p>24 be able to do it on the same particle because</p> <p>25 the PLM is usually done on a microscope slide</p>

Melinda Darby Dyar, Ph.D.

Page 118	Page 120
<p>1 and the TEM is done on a grid. So order is</p> <p>2 kind of irrelevant since it's different</p> <p>3 particles.</p> <p>4 Q. Different particles from the</p> <p>5 same sample?</p> <p>6 A. Yes.</p> <p>7 Q. Then presumably you would have</p> <p>8 photomicrographs of the particle that you're</p> <p>9 examining from the electron microscope,</p> <p>10 either images via TEM or SEM, correct?</p> <p>11 A. In this hypothetical situation,</p> <p>12 yes.</p> <p>13 Q. I mean, this hypothetical</p> <p>14 situation is I'm asking you to analyze a</p> <p>15 sample of talc to determine whether it has</p> <p>16 asbestos in it. You would take pictures with</p> <p>17 your electron microscope that are called</p> <p>18 photomicrographs to determine what the</p> <p>19 structure looked like visually, correct?</p> <p>20 MR. LOCKE: Objection.</p> <p>21 THE WITNESS: Well, in point of</p> <p>22 fact, you could also take</p> <p>23 photomicrographs with a polarized</p> <p>24 light microscope.</p> <p>25</p>	<p>1 yeah, there are written protocols</p> <p>2 about that.</p> <p>3 And, of course, basic polarized</p> <p>4 light microscope use is written up</p> <p>5 in -- ubiquitously in textbooks,</p> <p>6 including the outdated one that you</p> <p>7 gave me a section of.</p> <p>8 MR. CHACHKES: So I asked for a</p> <p>9 break about ten minutes ago. Are we</p> <p>10 getting near a point where we can</p> <p>11 break?</p> <p>12 MR. FINCH: Yeah. Two more</p> <p>13 questions.</p> <p>14 MR. CHACHKES: Okay.</p> <p>15 QUESTIONS BY MR. FINCH:</p> <p>16 Q. So you mentioned the tools that</p> <p>17 you would use would be to take your sample</p> <p>18 and, using an electron microscope, perform</p> <p>19 SAED and EDS, EDXA, on it; then use a</p> <p>20 polarized light microscope to analyze a</p> <p>21 different particle in the same sample.</p> <p>22 Correct?</p> <p>23 MR. FROST: Objection.</p> <p>24 Misstates testimony.</p> <p>25 MR. CHACHKES: Objection.</p>
Page 119	Page 121
<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. And --</p> <p>3 A. If the particles are big</p> <p>4 enough.</p> <p>5 Q. Right.</p> <p>6 And in those photomicrographs,</p> <p>7 either using TEM or PLM, you have a picture</p> <p>8 of the structure that you're analyzing,</p> <p>9 correct?</p> <p>10 A. You have a two-dimensional</p> <p>11 image of a particle viewed from one angle,</p> <p>12 yes.</p> <p>13 Q. And is it left to -- is there</p> <p>14 any written protocol or peer-reviewed</p> <p>15 literature that tells an analyst or scientist</p> <p>16 what it is to photograph or when to take the</p> <p>17 photomicrograph of the particle, either by</p> <p>18 PLM or TEM or SEM?</p> <p>19 MR. FROST: Objection.</p> <p>20 THE WITNESS: Well, for</p> <p>21 example, if you look in the Su paper</p> <p>22 that I've cited here, it talks pretty</p> <p>23 specifically about exactly how you</p> <p>24 would rotate the grain and examine it</p> <p>25 from different perspectives. So,</p>	<p>1 THE WITNESS: By definition, if</p> <p>2 you look at something on a polarized</p> <p>3 light microscope, generally speaking</p> <p>4 you're looking at something on a glass</p> <p>5 slide, not a TEM grid, yes.</p> <p>6 So if you're going to do</p> <p>7 multiple analyses of that sort, you</p> <p>8 would be using different particles</p> <p>9 from the same sample.</p> <p>10 QUESTIONS BY MR. FINCH:</p> <p>11 Q. And then you would have</p> <p>12 populations of -- an analysis of populations</p> <p>13 of particles?</p> <p>14 A. If you analyzed enough samples</p> <p>15 as is recommended in many of these protocols,</p> <p>16 you would have -- you could have --</p> <p>17 potentially have a population, yes.</p> <p>18 MR. FINCH: Okay. This is a</p> <p>19 good stopping point.</p> <p>20 VIDEOGRAPHER: Okay. Stand by,</p> <p>21 please. Remove your microphones. The</p> <p>22 time is 11:31 a.m. Off the record.</p> <p>23 (Off the record at 11:31 a.m.)</p> <p>24 VIDEOGRAPHER: Okay. We are</p> <p>25 back on the record. The time is</p>

31 (Pages 118 to 121)

Melinda Darby Dyar, Ph.D.

Page 122	Page 124
<p>1 11:47 a.m.</p> <p>2 QUESTIONS BY MR. FINCH:</p> <p>3 Q. Have you ever done any</p> <p>4 consulting work for Johnson & Johnson prior</p> <p>5 to your engagement in this case?</p> <p>6 A. No.</p> <p>7 Q. Have you ever done any</p> <p>8 consulting work for Imerys, Imerys Talc</p> <p>9 America, Imerys NA or any of their affiliated</p> <p>10 companies prior to your engagement by Johnson</p> <p>11 & Johnson in this case?</p> <p>12 A. No.</p> <p>13 Q. Have you ever done any</p> <p>14 consulting work for Colgate-Palmolive?</p> <p>15 A. No.</p> <p>16 Q. Have you ever done any</p> <p>17 consulting work for W.R. Grace?</p> <p>18 A. No.</p> <p>19 Q. Have you ever done any</p> <p>20 consulting work for the RJ Lee Group?</p> <p>21 A. No.</p> <p>22 Q. Have you ever done any</p> <p>23 consulting work for Scotts fertilizer</p> <p>24 company?</p> <p>25 A. No.</p>	<p>1 Q. In the -- I believe I might</p> <p>2 have asked you this before, but I'm not sure</p> <p>3 I remember the answer to it.</p> <p>4 Have you ever tested an NIST</p> <p>5 reference sample of asbestos using EDS, EDXA</p> <p>6 to determine what the EDS spectra looks like</p> <p>7 for tremolite or anthophyllite?</p> <p>8 A. No, but that wouldn't be</p> <p>9 necessary. EDS is a fairly basic technique.</p> <p>10 You could even synthesize the spectrum of</p> <p>11 those minerals and determine what they looked</p> <p>12 like, so it wouldn't be necessary to do it</p> <p>13 myself personally.</p> <p>14 Q. Would you agree with me that</p> <p>15 the transmission electron microscope, when it</p> <p>16 analyzes a reference samples of asbestos</p> <p>17 using EDS or EDXA, will -- is capable to</p> <p>18 print out an EDS spectra from that microscope</p> <p>19 that shows what the chemical makeup of the</p> <p>20 reference sample of asbestos is?</p> <p>21 A. Certainly an EDS spectrum can</p> <p>22 show you the presence or absence of</p> <p>23 particular elements, and it can give you a</p> <p>24 rough sense of how much of each is present.</p> <p>25 Q. In the third bullet point you</p>
Page 123	Page 125
<p>1 Q. Have you ever done any</p> <p>2 consulting work for BNSF Railway?</p> <p>3 A. No.</p> <p>4 Q. Have you ever been engaged to</p> <p>5 test vermiculite or to determine whether or</p> <p>6 not it contains asbestos?</p> <p>7 A. No.</p> <p>8 Q. Have you ever been hired by any</p> <p>9 entity to test a vermiculite-finished product</p> <p>10 to determine if it contains asbestos?</p> <p>11 A. No.</p> <p>12 Q. Have you ever been hired by any</p> <p>13 governmental entity to test any substance to</p> <p>14 determine whether it contains asbestos?</p> <p>15 A. No.</p> <p>16 Q. Have you ever been retained by</p> <p>17 any company that either mined talc or sold</p> <p>18 talc-containing finished products to analyze</p> <p>19 whether or not it contains asbestos?</p> <p>20 A. No.</p> <p>21 Q. All right. On page 1 of your</p> <p>22 report, you're talking about EDS mineral</p> <p>23 chemistry, correct, at the bottom of the</p> <p>24 page?</p> <p>25 A. Yes.</p>	<p>1 state, at the bottom of the page, "They,"</p> <p>2 referring to Longo and Rigler, "deliberately</p> <p>3 choose not to generate quantitative numbers</p> <p>4 that would more accurately determine the</p> <p>5 chemical compositions, which is the very</p> <p>6 purpose of an EDS analysis of an unknown</p> <p>7 mineral."</p> <p>8 Do you see that?</p> <p>9 A. Yes. I wrote that.</p> <p>10 Q. What generally accepted</p> <p>11 standards require the printout of</p> <p>12 quantitative data similar to Figure 7 in your</p> <p>13 report in order for a scientist or analyst to</p> <p>14 analyze the chemical structure of a mineral</p> <p>15 to determine whether it's consistent with</p> <p>16 asbestos or not?</p> <p>17 A. That was a big mouthful. Let</p> <p>18 me review that sentence.</p> <p>19 So as articulated by Newbury</p> <p>20 and Ritchie in their report about EDS</p> <p>21 spectroscopy and doing it accurately, it is</p> <p>22 important to do the calculations based on the</p> <p>23 peak areas with the appropriate corrections</p> <p>24 in order to get even semi-quantitative data</p> <p>25 out of an EDS spectrum.</p>

32 (Pages 122 to 125)

Melinda Darby Dyar, Ph.D.

Page 126	Page 128
<p>1 Q. Does anything in ISO 22262-1 or</p> <p>2 22262-2 or Yamate require the quantitative</p> <p>3 data like that shown in Figure 7 be generated</p> <p>4 in order for an analyst to analyze the</p> <p>5 chemical structure of a particle that could</p> <p>6 be asbestos?</p> <p>7 A. I don't recall. I'd have to go</p> <p>8 back and review them. But I'm guessing that</p> <p>9 because 22262 is about microscopic methods</p> <p>10 and 222-1 {sic} is about polarizing light</p> <p>11 microscopy, that neither one of them has much</p> <p>12 to say about EDS. I honestly don't recall</p> <p>13 which of those ISO documents talks about EDS.</p> <p>14 Q. Isn't it true that ISO 22262-1</p> <p>15 has an extensive discussion of analysis by</p> <p>16 TEM, quantitative analysis by TEM, of --</p> <p>17 qualitative analysis by TEM of EDXA spectra?</p> <p>18 A. As I said, I did not recall</p> <p>19 that, but I have it in my hand now and I'll</p> <p>20 be happy to take a look.</p> <p>21 Q. Page 33.</p> <p>22 A. Yes, I see it talks about --</p> <p>23 MR. FINCH: Can I have the</p> <p>24 Elmo?</p> <p>25 THE WITNESS: -- qualitative</p>	<p>1 dispersive X-ray analysis as used in asbestos</p> <p>2 analysis is semi-quantitative at best?"</p> <p>3 Do you see that?</p> <p>4 A. That is correct, but --</p> <p>5 Q. Do you agree with that?</p> <p>6 A. But let me point out that in</p> <p>7 his deposition, Dr. Longo says very</p> <p>8 specifically that it's quantitative, and that</p> <p>9 is exactly what I'm disagreeing with.</p> <p>10 Q. Are you aware of any ISO</p> <p>11 standard or EPA publication that requires the</p> <p>12 printout of quantitative data like you have</p> <p>13 in Figure 7 in your report in order to</p> <p>14 analyze the X-ray spectra of an asbestos --</p> <p>15 or potentially asbestos chemical?</p> <p>16 A. I am aware that analysis of ISO</p> <p>17 standards and under EPA requirements require</p> <p>18 that the mineral species be identified. And</p> <p>19 in order to identify the mineral species, it</p> <p>20 is necessary to have a quantitative -- as</p> <p>21 quantitative as possible chemical analysis.</p> <p>22 Q. Isn't it true that ISO 22262-1</p> <p>23 says nowhere that you have to have a</p> <p>24 quantitative analysis, or the quantitative</p> <p>25 printouts like you have in Figure 7 in your</p>
Page 127	Page 129
<p>1 analysis by TEM, yes.</p> <p>2 QUESTIONS BY MR. FINCH:</p> <p>3 Q. All right. Can you point me to</p> <p>4 any ISO standard or anywhere in Yamate where</p> <p>5 it says that it's necessary for an analyst to</p> <p>6 have quantitative data like that shown in</p> <p>7 Figure 7 in your report in order to analyze</p> <p>8 the chemical structure of an asbestos</p> <p>9 mineral?</p> <p>10 A. So the definition of asbestos</p> <p>11 requires that a mineral be one of the</p> <p>12 specific six regulated mineral species. And</p> <p>13 in order to determine if a mineral is among</p> <p>14 the six regulated mineral species, it is</p> <p>15 necessary to know the chemical composition</p> <p>16 and the crystal structure, as I describe in</p> <p>17 my report.</p> <p>18 Therefore, it follows that it</p> <p>19 would be useful to know the chemical</p> <p>20 composition in order to confirm whether one</p> <p>21 of the six regulated mineral species is</p> <p>22 present. And as articulated here, the TEM</p> <p>23 analysis is only qualitative.</p> <p>24 Q. And am I correct that in</p> <p>25 Yamate, for example, it states, "Energy-</p>	<p>1 report, in order to do a valid analysis of</p> <p>2 the chemical spectra of an asbestos particle?</p> <p>3 A. It is true that ISO 22262-1</p> <p>4 indicates that the asbestos is defined as one</p> <p>5 of specific mineral species. And so in order</p> <p>6 to determine if something is among a specific</p> <p>7 mineral species, you would have to know the</p> <p>8 chemical composition.</p> <p>9 Q. But it doesn't require you to</p> <p>10 have quantitative data in the level of detail</p> <p>11 that you show in Exhibit 7 to determine the</p> <p>12 chemical structure of the mineral, correct?</p> <p>13 A. It would be the chemical</p> <p>14 composition of a mineral.</p> <p>15 Q. The chemical composition of the</p> <p>16 mineral?</p> <p>17 A. It requires that you know the</p> <p>18 chemical composition well enough to identify</p> <p>19 the sample as one of the six regulated</p> <p>20 mineral species.</p> <p>21 Q. And do you have any view one</p> <p>22 way or another whether the analysts in</p> <p>23 Dr. Longo's lab, or Dr. Longo himself, is</p> <p>24 sufficiently familiar with the chemical</p> <p>25 composition of the six regulated types of</p>

Melinda Darby Dyar, Ph.D.

Page 130	Page 132
<p>1 asbestos that they can determine based on</p> <p>2 looking at a semi-quantitative EDXA spectra</p> <p>3 whether or not the material they're looking</p> <p>4 at has a chemical signature consistent with</p> <p>5 asbestos?</p> <p>6 A. I would say absolutely not,</p> <p>7 they do not have -- because it's impossible</p> <p>8 to look at -- no matter how many thousands of</p> <p>9 EDS spectra you've looked at, it is</p> <p>10 impossible to look at an EDS spectrum and,</p> <p>11 without analyzing it, obtain quantitative</p> <p>12 data as Dr. Longo purports to do.</p> <p>13 Q. Okay. In ISO 22262-1 -- do you</p> <p>14 have that?</p> <p>15 A. Got it.</p> <p>16 Q. You can do EDS, EDXA, by SEM or</p> <p>17 TEM, correct?</p> <p>18 A. Depends on the instrument, yes.</p> <p>19 Q. All right. Would you turn to</p> <p>20 Annex F.</p> <p>21 A. Yes.</p> <p>22 Q. All right. Would you agree</p> <p>23 with me that pages 58, 59, 60, 61, 62 all</p> <p>24 show EDS, EDXA spectra for samples of</p> <p>25 tremolite, anthophyllite and the other</p>	<p>1 A. No, sir. It says on --</p> <p>2 MR. LOCKE: Objection.</p> <p>3 THE WITNESS: -- page 1 of this</p> <p>4 document that this document is</p> <p>5 appropriate for the analysis of -- the</p> <p>6 quantitative -- qualitative analysis</p> <p>7 identification of asbestos in specific</p> <p>8 types of manufactured</p> <p>9 asbestos-containing products and</p> <p>10 commercial minerals.</p> <p>11 So I would say that these</p> <p>12 patterns have been developed for use</p> <p>13 in situations where you already know</p> <p>14 that what is present is asbestos, and</p> <p>15 you're trying to determine which of</p> <p>16 the six asbestos minerals is present,</p> <p>17 which is clearly not the case in the</p> <p>18 study of talc.</p> <p>19 QUESTIONS BY MR. FINCH:</p> <p>20 Q. Would you agree with me, or do</p> <p>21 you know, whether or not insulation can be</p> <p>22 asbestos-containing or non-asbestos-</p> <p>23 containing?</p> <p>24 MR. CHACHKES: Objection.</p> <p>25 THE WITNESS: I don't know</p>
Page 131	Page 133
<p>1 asbestos varieties?</p> <p>2 A. That is what this document</p> <p>3 claims to show, yes.</p> <p>4 Q. And you agree with me that</p> <p>5 nowhere in these printouts of what the</p> <p>6 chemical signature is using EDS, EDXA, does</p> <p>7 it have quantitative data like that shown in</p> <p>8 Figure 7 in your report?</p> <p>9 A. It is correct that those are</p> <p>10 not given; however, in the case of these</p> <p>11 reference standards, these have been</p> <p>12 independently analyzed for chemistry and,</p> <p>13 therefore, the chemistry is already known.</p> <p>14 And there is no need to determine the</p> <p>15 chemistry by this semi-quantitative EDXA</p> <p>16 analytical method, which is why it probably</p> <p>17 isn't shown here.</p> <p>18 Q. Isn't it the case that what</p> <p>19 this ISO 22262-1 is all about is determining</p> <p>20 when you've got a bulk material where you</p> <p>21 don't know whether it has asbestos or not in</p> <p>22 it, to do an EDS or EDXA to compare the data</p> <p>23 you get from the bulk material to the</p> <p>24 standard EDS, EDXA spectrum contained in</p> <p>25 Annex F?</p>	<p>1 anything about that.</p> <p>2 QUESTIONS BY MR. FINCH:</p> <p>3 Q. Okay. Would you agree with me,</p> <p>4 or do you know, whether ISO 22262 can be used</p> <p>5 to test insulation, where you don't know</p> <p>6 whether it has asbestos in it or not, to</p> <p>7 determine whether or not the bulk material</p> <p>8 that you're looking at contains asbestos?</p> <p>9 A. I believe it says</p> <p>10 asbestos-containing insulation.</p> <p>11 And it goes on to talk about --</p> <p>12 in the introduction about asbestos-containing</p> <p>13 insulation. For example, "A large proportion</p> <p>14 of the chrysotile product produced was used</p> <p>15 in asbestos cement products. Materials</p> <p>16 containing high proportions of chrysotile</p> <p>17 asbestos were used in buildings and in</p> <p>18 industry."</p> <p>19 So that's what it says here.</p> <p>20 Q. Isn't it true that in the scope</p> <p>21 on page 1 of the document, this part of ISO</p> <p>22 22262 specifies methods for sampling bulk</p> <p>23 materials and identification of asbestos in</p> <p>24 commercial bulk materials?</p> <p>25 It doesn't say anything about</p>

Melinda Darby Dyar, Ph.D.

Page 134	Page 136
<p>1 asbestos-containing bulk materials, correct?</p> <p>2 A. It indeed says it specifies</p> <p>3 methods for sampling bulk materials and</p> <p>4 identification of asbestos in commercial bulk</p> <p>5 asbestos. That's what it says here, yes.</p> <p>6 Q. All right. Do you have the</p> <p>7 understanding one way or another that this is</p> <p>8 the methodology a scientist should follow if</p> <p>9 he has a bulk material of insulation that he</p> <p>10 doesn't know whether it has asbestos in it or</p> <p>11 not, to follow this methodology to determine</p> <p>12 whether there's asbestos in the material or</p> <p>13 not?</p> <p>14 A. To which methodology are you</p> <p>15 referring? The entire document?</p> <p>16 Q. ISO -- yes.</p> <p>17 A. This document and the extended</p> <p>18 versions 2 and 3 are intended for that</p> <p>19 purpose. That's what it says they're</p> <p>20 intended for.</p> <p>21 Q. Okay. Would you agree with me</p> <p>22 that Annex F has the X-ray spectra for</p> <p>23 tremolite on page 61?</p> <p>24 A. It does include spectra of</p> <p>25 samples of these minerals, yes. Certainly</p>	<p>1 analysis where it specifically focuses on the</p> <p>2 example of asbestos. I believe it's level 3.</p> <p>3 Let me see if I can find that.</p> <p>4 Sorry, what was your question?</p> <p>5 Q. My question is, isn't the</p> <p>6 entire Yamate protocol something that is used</p> <p>7 to determine whether or not asbestos is in a</p> <p>8 material or not?</p> <p>9 A. Well, the title of the document</p> <p>10 is "Methodology for Measurement of Airborne</p> <p>11 Asbestos By Electron Microscopy."</p> <p>12 So the level 3 as specified in</p> <p>13 this document details the use of quantitative</p> <p>14 SAED analysis from two different zone axis</p> <p>15 orientations, et cetera, et cetera.</p> <p>16 Q. Right.</p> <p>17 But before you get to</p> <p>18 quantitative level 3 analysis, you do level 2</p> <p>19 analysis, correct?</p> <p>20 A. That's correct.</p> <p>21 Q. And level 2 analysis, you're</p> <p>22 trying to determine whether or not there is</p> <p>23 asbestos in the material or not, correct?</p> <p>24 May have asbestos in it, may not?</p> <p>25 A. At -- at significant -- at</p>
Page 135	Page 137
<p>1 these are not necessarily representative of</p> <p>2 all possible examples of these minerals, but</p> <p>3 they are individual standard reference</p> <p>4 materials of these particular individuals</p> <p>5 {sic}.</p> <p>6 Q. Are you aware whether tremolite</p> <p>7 was ever used as part of any -- an</p> <p>8 asbestos-containing product, intentionally</p> <p>9 designed to be part of an asbestos-containing</p> <p>10 product?</p> <p>11 MR. FROST: Objection.</p> <p>12 THE WITNESS: I have no</p> <p>13 knowledge of that.</p> <p>14 QUESTIONS BY MR. FINCH:</p> <p>15 Q. Do you recognize the Yamate</p> <p>16 method as a method to analyze -- to determine</p> <p>17 whether or not there is or is not asbestos in</p> <p>18 either a bulk sample or in the air?</p> <p>19 A. The Yamate method is, strictly</p> <p>20 speaking, a method for measurement of</p> <p>21 airborne asbestos.</p> <p>22 Q. And is it part of the method to</p> <p>23 determine whether or not -- whether asbestos</p> <p>24 is there or not?</p> <p>25 A. So let's take a look at level 3</p>	<p>1 significant levels, yes.</p> <p>2 Q. And it doesn't require the</p> <p>3 analyst, in looking at an EDS, EDXA spectrum,</p> <p>4 to have the quantitative data like that shown</p> <p>5 in Figure 7 in your report to determine the</p> <p>6 chemical composition of the material he or</p> <p>7 she is analyzing, correct?</p> <p>8 A. Well, in point of fact, level 2</p> <p>9 is level 1 plus chemical analysis. And it</p> <p>10 says that -- in level 2 you're talking about</p> <p>11 a process of elimination used to categorize</p> <p>12 amphibole fibers, identify the ambiguous</p> <p>13 fibers in concern or validate level of</p> <p>14 chrysotile fibers. So it all builds.</p> <p>15 What was your question?</p> <p>16 Q. My question is, is there</p> <p>17 anything in the Yamate document that requires</p> <p>18 an analyst to have quantitative data like</p> <p>19 Figure 7 in your report for the EDS, EDXA</p> <p>20 analysis he or she performs on a material to</p> <p>21 determine whether its chemical composition is</p> <p>22 consistent with asbestos?</p> <p>23 A. Well, I guess maybe read the</p> <p>24 question again here.</p> <p>25 The Yamate document is about</p>

Melinda Darby Dyar, Ph.D.

Page 138	Page 140
<p>1 confirming whether it's one of the specific</p> <p>2 asbestos mineral species. And so to the</p> <p>3 extent that it is necessary to have chemical</p> <p>4 analysis to determine whether something is</p> <p>5 one of the species, then, yes, it does imply</p> <p>6 that you need to have quantitative EDS data.</p> <p>7 Q. Where? Where? Point me to</p> <p>8 where it says you have to have quantitative</p> <p>9 EDS data.</p> <p>10 A. It says that you need to</p> <p>11 identify a specific -- whether a specific</p> <p>12 asbestiform or potentially asbestiform</p> <p>13 mineral species is present. And to me, that</p> <p>14 implies that you need to know what the</p> <p>15 chemistry is because otherwise you couldn't</p> <p>16 tell.</p> <p>17 Q. And isn't it correct that at</p> <p>18 page 39 of the document it states,</p> <p>19 "Energy-dispersive X-ray analysis, as used in</p> <p>20 asbestos analysis, is semi-quantitative at</p> <p>21 best"?</p> <p>22 A. Absolutely, yes.</p> <p>23 Q. And it says nowhere in here</p> <p>24 that you have to have quantitative EDS or ED</p> <p>25 X-ray analysis.</p>	<p>1 report.</p> <p>2 Q. Published in the peer-reviewed</p> <p>3 literature?</p> <p>4 A. Not a commonly cited journal,</p> <p>5 but, yes.</p> <p>6 Q. In this journal, he reports EDS</p> <p>7 data from various materials in Figures 5, 6,</p> <p>8 8?</p> <p>9 A. Yes.</p> <p>10 Q. And in the EDS data he reports,</p> <p>11 for example, in Figure 6, three SEM</p> <p>12 photographs with associated EDS data of</p> <p>13 amphiboles found in soils in Washington, DC,</p> <p>14 southern Illinois, western Montana. Based on</p> <p>15 EDS data, particles A and B would be</p> <p>16 tremolite, actinolite, and C would be</p> <p>17 anthophyllite, grunerite.</p> <p>18 Do you see that?</p> <p>19 A. He just says based on EDS data;</p> <p>20 he doesn't say based on the EDS data shown.</p> <p>21 So my inference from this figure caption</p> <p>22 would be that he calculated the mineral</p> <p>23 compositions and drew those conclusions.</p> <p>24 Now, he does not say that he's</p> <p>25 basing his conclusions about composition on</p>
Page 139	Page 141
<p>1 Can you point to me anywhere in</p> <p>2 this document where it says must have a</p> <p>3 quantitative data like that shown in</p> <p>4 Exhibit 7 {sic} in your report?</p> <p>5 A. So I would say that nowhere in</p> <p>6 this document does it says that you must have</p> <p>7 a quantitative printout, but certainly that</p> <p>8 information is necessary to determine whether</p> <p>9 something is a particular composition.</p> <p>10 So again, referring back to my</p> <p>11 report, the goal of Drs. Longo and Rigler is</p> <p>12 to confirm the presence of one of the six</p> <p>13 regulated asbestiform -- potentially</p> <p>14 asbestiform minerals and whether or not they</p> <p>15 are present in the talcum powder. And the</p> <p>16 EDS data that are presented in there do not</p> <p>17 come anywhere close to determining that.</p> <p>18 MR. FINCH: Can I have the</p> <p>19 Gunther paper?</p> <p>20 (Dyar Exhibit 11 marked for</p> <p>21 identification.)</p> <p>22 QUESTIONS BY MR. FINCH:</p> <p>23 Q. This is a paper by Mickey</p> <p>24 Gunther that you cite in your report?</p> <p>25 A. Yes, I use the figures in my</p>	<p>1 the basis of these images alone.</p> <p>2 Q. Does it say anywhere in the</p> <p>3 paper that he calculated the quantitative EDS</p> <p>4 measurement?</p> <p>5 A. He doesn't need to. It is --</p> <p>6 it is extraordinarily rare for someone to</p> <p>7 acquire an EDS pattern and not calculate the</p> <p>8 composition. So you would only need to</p> <p>9 mention that if you didn't calculate the</p> <p>10 composition.</p> <p>11 Q. Does it say anywhere in this</p> <p>12 paper that you -- that he calculated -- he</p> <p>13 did some kind of quantitative analysis --</p> <p>14 first of all, let's get very clear.</p> <p>15 Nothing in this peer-reviewed</p> <p>16 paper has the kind of quantitative data</p> <p>17 relating to an EDS spectrum like that shown</p> <p>18 in Figure 7 in your report, correct?</p> <p>19 MR. CHACHKES: Objection.</p> <p>20 THE WITNESS: I would want to</p> <p>21 make sure there isn't some supplement</p> <p>22 that gives those numbers, but</p> <p>23 certainly in these five pages of this</p> <p>24 document he doesn't give the</p> <p>25 quantitative numbers. However, he</p>

Melinda Darby Dyar, Ph.D.

Page 142	Page 144
<p>1 does state that based on EDS data, 2 these particles would be assigned 3 these compositions. 4 So again, the norm when doing 5 analysis with EDS is that you 6 calculate the compositions. It would 7 be extraordinary that he would have to 8 go out of his way to not print them 9 out, which is, in fact, what 10 Drs. Longo and Rigler do. They must 11 have disabled the default command to 12 output compositions. 13 QUESTIONS BY MR. FINCH: 14 Q. You say the norm. 15 You haven't pointed me to a 16 single document, either ISO standard, Yamate 17 standard, peer-reviewed literature, that says 18 that you have to print out the quantitative 19 EDS, EDXA graph -- graphics like in Figure 7, 20 have you, ma'am? 21 MR. LOCKE: Objection. 22 THE WITNESS: So in my report, 23 I cite the Newbury and Ritchie paper 24 which goes in excruciating detail of 25 how the appropriate -- of the</p>	<p>1 identification.) 2 QUESTIONS BY MR. FINCH: 3 Q. Professor Dyar, do you have an 4 article entitled "Tremolite Mesothelioma" by 5 Victor Roggli and other scientists at Duke 6 University published in the peer-reviewed 7 literature in 2002? 8 A. Yes, sir. 9 Q. All right. In... 10 A. I immediately note that the 11 authors of this paper are medical personnel 12 involved with pathology, and there is no 13 indication that any of them is a 14 mineralogist. 15 Q. And they are publishing in the 16 peer-reviewed literature about various types 17 of asbestos fibers found in human tissue, 18 correct? 19 A. Well, I'd have to have some 20 time to speed-read this paper, but the title 21 is called "Tremolite Mesothelioma," so I'd 22 have to assume that that's what the paper is 23 about. 24 Q. And in Figure 1 -- actually, on 25 page 448, in the second column the authors</p>
Page 143	Page 145
<p>1 appropriate methodology for using EDS. 2 And they talk in that at length about 3 the different methods for making 4 calculations that determine 5 quantitative or semi-quantitative data 6 from an EDS spectrum. 7 So again, Newbury and Ritchie 8 is a good example of what is the 9 convention in this field, which is to 10 always acquire the EDS spectrum and 11 then print out the compositions that 12 are calculated by the instrument. 13 QUESTIONS BY MR. FINCH: 14 Q. Well, Dr. Gunther did not print 15 out the calculations in his 2010 paper, 16 correct? 17 MR. FROST: Objection. 18 THE WITNESS: He refers to the 19 SEM data, but he does not explicitly 20 include them, probably for reasons of 21 space. That printout would be pretty 22 tiny in a publication of this sort. 23 MR. FINCH: Can I have the 24 Roggli paper? 25 (Dyar Exhibit 12 marked for</p>	<p>1 write, "The elemental composition of 2 individual mineral fibers was detected by 3 means of energy-dispersive X-ray analysis, 4 EDXA." 5 Do you see that? 6 A. I'm looking. 7 Q. About halfway down, first 8 column -- I mean, the second column. 9 A. Yes. So that to me implies 10 that they output the compositions. 11 Q. In the paper they publish "the 12 energy-dispersive X-ray spectra for 13 tremolite, actinolite, anthophyllite and 14 chrysotile. Characteristic elemental 15 composition for each fiber type is shown. 16 The gold piece is due to sputter coating of 17 the sample to reduce charging artifacts." 18 Do you see that? 19 A. I see that. And it is my 20 opinion, based on being an associate editor 21 of the American Mineralogist for 20 years, 22 that no self-respecting mineralogical journal 23 would publish a figure like this. This is 24 insufficient for any kind of chemical 25 analysis.</p>

37 (Pages 142 to 145)

Melinda Darby Dyar, Ph.D.

Page 146	Page 148
<p>1 Q. So these doctors are doing</p> <p>2 chemical analysis of the asbestos fibers they</p> <p>3 found in human tissue, and they're printing</p> <p>4 out the EDXA results in Figure 1. And they</p> <p>5 do not include the quantitative data like you</p> <p>6 show in Figure 7 in your report, correct?</p> <p>7 MR. FROST: Objection. Form.</p> <p>8 THE WITNESS: Well, I'd have to</p> <p>9 look and make sure there isn't a</p> <p>10 supplement to this particular article,</p> <p>11 and I'd need a little more time to</p> <p>12 inspect it.</p> <p>13 For example, I'd like to know</p> <p>14 how did they -- how did they identify</p> <p>15 the samples as asbestos in the first</p> <p>16 place. I don't see any other evidence</p> <p>17 of any other kinds of analytical</p> <p>18 techniques done in here.</p> <p>19 I'd need to look at this much</p> <p>20 more carefully, but it is certainly my</p> <p>21 opinion that you couldn't use EDXA to</p> <p>22 identify these -- distinguish between</p> <p>23 these particular minerals.</p> <p>24 So I -- these people may be</p> <p>25 well-respected pathologists, but this</p>	<p>1 Q. Am I correct that on pages 526,</p> <p>2 527, 528, and in 529, 530, which is Figures</p> <p>3 1912 to 1919, all contain EDS spectra for</p> <p>4 different minerals?</p> <p>5 A. 526. Yes. They're simulated</p> <p>6 patterns, yes.</p> <p>7 Q. And am I correct that none of</p> <p>8 these figures have the quantitative data like</p> <p>9 Figure 7 in your report shown in the -- in</p> <p>10 the pages of your textbook?</p> <p>11 A. They don't include the</p> <p>12 compositions because they are simulated</p> <p>13 patterns, and simulated patterns are created</p> <p>14 by inputting a composition. So there is no</p> <p>15 need to output the composition because these</p> <p>16 are simulated patterns that are created using</p> <p>17 an input -- a specifically input composition.</p> <p>18 MR. FINCH: Can I have the</p> <p>19 other excerpt from that book?</p> <p>20 (Dyar Exhibit 14 marked for</p> <p>21 identification.)</p> <p>22 QUESTIONS BY MR. FINCH:</p> <p>23 Q. This is Exhibit 14, which is</p> <p>24 another page of that book, page 182.</p> <p>25 What does Figure 9.17 show?</p>
Page 147	Page 149
<p>1 particular figure and these</p> <p>2 conclusions would never be published</p> <p>3 in a journal that was peer-reviewed by</p> <p>4 mineralogists.</p> <p>5 QUESTIONS BY MR. FINCH:</p> <p>6 Q. Are you familiar with a book</p> <p>7 entitled "Mineralogy and Optical Mineralogy"</p> <p>8 written by Melinda Darby Dyar and Mickey</p> <p>9 Gunther?</p> <p>10 A. Indeed I am.</p> <p>11 While we are here, let me draw</p> <p>12 your attention to page 607, where it gives</p> <p>13 the revised amphibole nomenclature, which was</p> <p>14 published in 1997 and 2004. So this is the</p> <p>15 appropriate amphibole nomenclature to be</p> <p>16 using.</p> <p>17 MR. FINCH: Move to strike as</p> <p>18 nonresponsive to any question pending.</p> <p>19 (Dyar Exhibit 13 marked for</p> <p>20 identification.)</p> <p>21 QUESTIONS BY MR. FINCH:</p> <p>22 Q. Do you recognize this as the</p> <p>23 cover page, table of contents, preface and</p> <p>24 Chapter 19 from your 2008 book?</p> <p>25 A. Yes.</p>	<p>1 A. It shows the EDS output of an</p> <p>2 Idaho star garnet from an SEM.</p> <p>3 Q. Does it include the</p> <p>4 quantitative data that is shown in Figure 7</p> <p>5 in your report?</p> <p>6 A. No, and it wouldn't have been</p> <p>7 appropriate to include that.</p> <p>8 First of all, the print would</p> <p>9 be too small, and second of all, the point</p> <p>10 here is to just show what an EDS spectrum</p> <p>11 looks like. It's not our intent here in this</p> <p>12 particular chapter to show -- or in this</p> <p>13 particular figure to show anything</p> <p>14 quantitative, so it wouldn't have been</p> <p>15 appropriate to include the chemistry.</p> <p>16 So in other words, we're not</p> <p>17 trying to identify what mineral this is. We</p> <p>18 already know that it's an Idaho star garnet,</p> <p>19 so we don't need to output the chemistry to</p> <p>20 show anything about its chemical composition.</p> <p>21 In fact, it's highly likely</p> <p>22 that we have an independent and much more</p> <p>23 accurate chemical composition from electron</p> <p>24 microprobe, and we just didn't feel it was</p> <p>25 necessary or appropriate to include it here.</p>

Melinda Darby Dyar, Ph.D.

Page 150	Page 152
<p>1 Q. On page 531 of Exhibit 13?</p> <p>2 A. Uh-huh.</p> <p>3 Q. Here you're not looking at a</p> <p>4 simulated material, correct?</p> <p>5 You're looking at an</p> <p>6 approximately 5-micron-wide particle mounted</p> <p>7 on a fiber similar to the example shown in</p> <p>8 Figure 1920, images modified from Gunther's</p> <p>9 2007 paper, correct?</p> <p>10 A. Correct.</p> <p>11 Q. So then you are -- in the</p> <p>12 part C, higher magnification SEM image of the</p> <p>13 same particle with analysis points for the</p> <p>14 SEM beam indicated by 1 and 2. That's an EDS</p> <p>15 spectrum there, correct?</p> <p>16 A. Wait a minute. I'm not -- I'm</p> <p>17 not following you. Where are you?</p> <p>18 Q. Yeah. The bottom,</p> <p>19 Figure 19.21.</p> <p>20 A. Oh, sorry. I'm on the wrong</p> <p>21 page.</p> <p>22 Yep.</p> <p>23 Q. On this basis, the particle</p> <p>24 could be either a pyroxene or an amphibole;</p> <p>25 however, the refractive indices shows this</p>	<p>1 to characterize the chemical composition of a</p> <p>2 mineral, correct?</p> <p>3 A. Again, it would not be</p> <p>4 appropriate to include that in this</p> <p>5 particular context. This is a textbook, not</p> <p>6 a research -- not a research thing. And the</p> <p>7 point of this figure is to show how difficult</p> <p>8 it is to distinguish things purely from</p> <p>9 visual examination. In other words, he's</p> <p>10 saying you really need more information.</p> <p>11 And as I said in my report, the</p> <p>12 way to get more information would be to</p> <p>13 output the quantitative chemical data that</p> <p>14 the TEM and the SEM are easily able to</p> <p>15 provide.</p> <p>16 So this is not an appropriate</p> <p>17 place to include chemical data.</p> <p>18 MR. FINCH: Can I have the 2016</p> <p>19 Gunther paper and the IC 420 document?</p> <p>20 (Dyar Exhibit 15 marked for</p> <p>21 identification.)</p> <p>22 QUESTIONS BY MR. FINCH:</p> <p>23 Q. Here's Exhibit 15.</p> <p>24 Do you have Exhibit 15 in front</p> <p>25 of you, ma'am?</p>
Page 151	Page 153
<p>1 particle is an amphibole. Choosing a species</p> <p>2 name between tremolite and actinolite would</p> <p>3 be difficult.</p> <p>4 And the EDS of the grain there</p> <p>5 shows the chemical signature of an amphibole,</p> <p>6 correct?</p> <p>7 A. No, I think you're misreading</p> <p>8 that. It basically says on the basis of the</p> <p>9 EDS spectrum, it could be either a pyroxene</p> <p>10 or an amphibole.</p> <p>11 This is exactly the same point</p> <p>12 I make in the figure -- let's see -- in</p> <p>13 Figure 4 of my report where it says that on</p> <p>14 the basis of an EDS spectrum, these minerals</p> <p>15 are indistinguishable.</p> <p>16 So then he goes on to say that</p> <p>17 because of the refractive index data, in</p> <p>18 other words, the optimal microscopy, the PLM,</p> <p>19 it is possible to constrain the identify --</p> <p>20 the identity of this mineral to be an</p> <p>21 amphibole. But that's all you can tell.</p> <p>22 Q. But you don't print out the</p> <p>23 quantitative data like that shown in Figure 7</p> <p>24 of your report in this section of your</p> <p>25 textbook where you're using an EDS spectrum</p>	<p>1 A. I do.</p> <p>2 Q. This is -- one of the coauthors</p> <p>3 of this paper is your coauthor, Mickey</p> <p>4 Gunther?</p> <p>5 A. I see that.</p> <p>6 Q. Another is Dr. Roggli, whose</p> <p>7 paper we looked at a few minutes ago?</p> <p>8 A. Yes.</p> <p>9 Q. This is a case report of</p> <p>10 "Erionite-Associated Malignant Pleural</p> <p>11 Mesothelioma in Mexico," published in the</p> <p>12 peer-reviewed journal International Journal</p> <p>13 of Clinical and Experimental Pathology?</p> <p>14 A. I see that.</p> <p>15 Q. And you have two geologists</p> <p>16 publishing this paper along with Dr. Roggli,</p> <p>17 and the lead author's name I'm not going to</p> <p>18 try to pronounce because I'll butcher it.</p> <p>19 But there's about eight authors, and two of</p> <p>20 them are geologists, correct?</p> <p>21 A. I see that, yes.</p> <p>22 Q. And two of them are geologists</p> <p>23 that you have published with yourself,</p> <p>24 correct?</p> <p>25 A. Yes.</p>

39 (Pages 150 to 153)

Melinda Darby Dyar, Ph.D.

Page 154	Page 156
<p>1 Q. And what they're doing is they</p> <p>2 are analyzing fibers found in the tissue of a</p> <p>3 human being to determine the nature of the</p> <p>4 particles in their mesothelioma, correct?</p> <p>5 MR. LOCKE: Objection.</p> <p>6 THE WITNESS: I need a little</p> <p>7 more time to look at this paper before</p> <p>8 I could tell you exactly what they</p> <p>9 were doing.</p> <p>10 QUESTIONS BY MR. FINCH:</p> <p>11 Q. Well, do you recognize Figure 3</p> <p>12 and Figure 6 and Figure 4 as all containing</p> <p>13 EDXA or EDS spectrum of materials that</p> <p>14 they're analyzing?</p> <p>15 A. I see that those figures do</p> <p>16 contain EDS spectra, yes.</p> <p>17 Q. All right. So in Figure 3 on</p> <p>18 page 5727 -- and this is a scientific paper</p> <p>19 where they're reporting on finding erionite</p> <p>20 fibers in someone's mesothelioma.</p> <p>21 That's at least the title of</p> <p>22 the paper, correct?</p> <p>23 MR. LOCKE: Objection.</p> <p>24 THE WITNESS: The title of the</p> <p>25 paper is "Erionite-Associated</p>	<p>1 quantitative data that you say is required</p> <p>2 for a scientific analysis like that shown in</p> <p>3 Figure 7 in your report, correct?</p> <p>4 A. In fact, in my report there are</p> <p>5 no independent constraints on where the</p> <p>6 particles are coming from.</p> <p>7 In this report, it appears to</p> <p>8 me that the particles are coming from a</p> <p>9 repairman who was raised on a farm in the</p> <p>10 Mexico volcanic belt, presumably near a</p> <p>11 source of erionite. So I'd have to spend</p> <p>12 more time with this paper.</p> <p>13 But it appears to me that they</p> <p>14 already knew that this was erionite, and they</p> <p>15 were simply confirming that the EDS spectra</p> <p>16 were consistent with that. And in that case,</p> <p>17 it's not necessary to print out the chemical</p> <p>18 composition.</p> <p>19 In the case of the particles</p> <p>20 being studied by Drs. Longo and Rigler, we</p> <p>21 have no such knowledge. We have no idea and</p> <p>22 no independent constraints on what mineral it</p> <p>23 could be or what the composition could be.</p> <p>24 And, therefore, it is their obligation to</p> <p>25 produce as much quantitative information as</p>
Page 155	Page 157
<p>1 Malignant Pleural Mesothelioma in</p> <p>2 Mexico." That's the title.</p> <p>3 QUESTIONS BY MR. FINCH:</p> <p>4 Q. All right. Figure 3, part B,</p> <p>5 is the data that they choose to report in</p> <p>6 this peer-reviewed paper, "Energy-Dispersive</p> <p>7 Spectrum from an Erionite Fiber Showing Peaks</p> <p>8 for Aluminum and Silicone."</p> <p>9 "There's a suggestion of</p> <p>10 smaller peaks for sodium and iron. Platinum</p> <p>11 peaks are from sputter contained in the</p> <p>12 sample for imaging purposes."</p> <p>13 Do you see that?</p> <p>14 A. I see that it says that, yes.</p> <p>15 Q. All right. And so what that is</p> <p>16 is an EDS or EDXA spectrum of a reference</p> <p>17 sample of erionite, correct?</p> <p>18 A. I don't see where it says that.</p> <p>19 Q. Well, would you agree with me</p> <p>20 that the authors call it an EDS spectrum from</p> <p>21 an erionite fiber? That's what they call it</p> <p>22 in the paper?</p> <p>23 A. That's what it says right here</p> <p>24 in the caption to Figure 3.</p> <p>25 Q. And they don't print out the</p>	<p>1 possible.</p> <p>2 So again, I would need some</p> <p>3 further study to address specific questions</p> <p>4 about this paper, but my understanding is</p> <p>5 that they're simply showing that the SEM</p> <p>6 images and the EDS analyses are consistent</p> <p>7 with their existing supposition that this is</p> <p>8 erionite.</p> <p>9 Q. And their existing supposition</p> <p>10 that this is erionite is based on testing</p> <p>11 that people have done of the soil in Mexico</p> <p>12 where they found erionite fibers, right?</p> <p>13 A. I don't --</p> <p>14 MR. FROST: Objection. Form.</p> <p>15 THE WITNESS: I don't know that</p> <p>16 for a fact. I'd have to take much</p> <p>17 more time to review this paper.</p> <p>18 QUESTIONS BY MR. FINCH:</p> <p>19 Q. All right. So Figure 6 has a</p> <p>20 EDX spectra of Mexican soil with erionite,</p> <p>21 correct?</p> <p>22 A. That's what it says here.</p> <p>23 Q. And again, there's no</p> <p>24 quantitative data printed out in Figure 6 C,</p> <p>25 correct?</p>

40 (Pages 154 to 157)

Melinda Darby Dyar, Ph.D.

Page 158	Page 160
<p>1 A. Again --</p> <p>2 Q. Of the type -- of the type that</p> <p>3 is shown in Exhibit 7 {sic} in your report,</p> <p>4 Figure 7 in your report?</p> <p>5 A. There are no chemical analyses</p> <p>6 printed out here because it would not be</p> <p>7 appropriate. They already know it's erionite</p> <p>8 based on, it looks like, independent studies.</p> <p>9 Q. Okay. They already know it's</p> <p>10 erionite based on independent studies.</p> <p>11 How do you know that Dr. Longo</p> <p>12 and Dr. Rigler don't already know that there</p> <p>13 is tremolite and anthophyllite asbestos in</p> <p>14 the Vermont talc based on independent studies</p> <p>15 that other analysts have done?</p> <p>16 MR. FROST: Objection to form.</p> <p>17 MR. LOCKE: Objection.</p> <p>18 MR. CHACHKES: Objection.</p> <p>19 THE WITNESS: There is no</p> <p>20 evidence in Drs. Longo and Rigler's</p> <p>21 reports, plural, that they have any</p> <p>22 data that confirm that any of the</p> <p>23 particles they studied are asbestos.</p> <p>24 Perhaps that's a good place to</p> <p>25 break for lunch.</p>	<p>1 do you?</p> <p>2 MR. CHACHKES: Objection.</p> <p>3 MR. FROST: Objection.</p> <p>4 THE WITNESS: As I said at the</p> <p>5 outset of this question period, I</p> <p>6 looked at all the references cited by</p> <p>7 Drs. Longo and Rigler and read the</p> <p>8 ones that were available to me. So I</p> <p>9 do not recall them alluding to any</p> <p>10 such testing reports.</p> <p>11 QUESTIONS BY MR. FINCH:</p> <p>12 Q. And if they had, they have that</p> <p>13 as a source of their basis for knowledge, you</p> <p>14 don't know about it, right?</p> <p>15 MR. CHACHKES: Objection.</p> <p>16 THE WITNESS: I can't read the</p> <p>17 minds of Drs. Longo and Rigler, no.</p> <p>18 QUESTIONS BY MR. FINCH:</p> <p>19 Q. You can read the trial</p> <p>20 testimony and the discussion of the Johnson &</p> <p>21 Johnson tests and documents of Dr. Longo in</p> <p>22 multiple ovarian cancer and asbestos cases,</p> <p>23 and you haven't done that, correct?</p> <p>24 MR. CHACHKES: Objection.</p> <p>25 MR. FROST: Objection.</p>
Page 159	Page 161
<p>1 MR. CHACHKES: It is lunchtime.</p> <p>2 It's kind of 12 what? 12:40?</p> <p>3 MR. FINCH: Let me have two</p> <p>4 follow-up questions based on that.</p> <p>5 QUESTIONS BY MR. FINCH:</p> <p>6 Q. You haven't reviewed anybody's</p> <p>7 testing of talc from the Windsor mines in</p> <p>8 Vermont, have you, ma'am?</p> <p>9 MR. FROST: Objection.</p> <p>10 MR. CHACHKES: Objection.</p> <p>11 QUESTIONS BY MR. FINCH:</p> <p>12 Q. Other than Longo and Rigler?</p> <p>13 A. I was asked --</p> <p>14 MR. CHACHKES: Objection.</p> <p>15 THE WITNESS: -- to review the</p> <p>16 methodology of Drs. Longo and Rigler,</p> <p>17 and that's what I did.</p> <p>18 QUESTIONS BY MR. FINCH:</p> <p>19 Q. You don't know what Johnson &</p> <p>20 Johnson documents they have reviewed, they'd</p> <p>21 given the same kind of information about the</p> <p>22 potential for tremolite asbestos and</p> <p>23 anthophyllite asbestos to be in those mines</p> <p>24 that the authors of the 2016 paper that's</p> <p>25 Exhibit 15 have about the erionite in Mexico,</p>	<p>1 THE WITNESS: I have not done</p> <p>2 that because it would not be relevant</p> <p>3 to my task, which was to evaluate</p> <p>4 their methodology.</p> <p>5 MR. FINCH: All right. This is</p> <p>6 a good time to break for lunch.</p> <p>7 VIDEOGRAPHER: Okay. Please</p> <p>8 remove your microphones. The time is</p> <p>9 12:37 p.m. Off the record.</p> <p>10 (Off the record at 12:37 p.m.)</p> <p>11 VIDEOGRAPHER: Okay. We are</p> <p>12 back on the record. The time is</p> <p>13 1:22 p.m.</p> <p>14 QUESTIONS BY MR. FINCH:</p> <p>15 Q. Good afternoon, Ms. Darby Dyar.</p> <p>16 We are back on the record after a lunch</p> <p>17 break.</p> <p>18 Did you review any documents</p> <p>19 over the lunch break?</p> <p>20 A. No.</p> <p>21 Q. You were talking about, in</p> <p>22 connection with the erionite paper that I</p> <p>23 just showed you, the scientists who wrote</p> <p>24 that paper had information that erionite was</p> <p>25 a possible mineral in the soil in Mexico,</p>

41 (Pages 158 to 161)

Melinda Darby Dyar, Ph.D.

Page 162	Page 164
<p>1 correct?</p> <p>2 Do you recall that discussion?</p> <p>3 A. Let me pull the paper out and</p> <p>4 take a look at it.</p> <p>5 So, yes, what I said was it</p> <p>6 appears that this is a report based on</p> <p>7 results from a vehicle repairman who was</p> <p>8 raised on a farm in the Mexican volcanic belt</p> <p>9 region.</p> <p>10 Q. And what information did the</p> <p>11 scientists have that led them to suspect that</p> <p>12 erionite might be in that region of the</p> <p>13 world?</p> <p>14 MR. FROST: Objection.</p> <p>15 THE WITNESS: You know, this</p> <p>16 paper is seven pages long. I'd happy</p> <p>17 to take the time to read it. But I</p> <p>18 would need time, to answer that</p> <p>19 question, to read this paper.</p> <p>20 QUESTIONS BY MR. FINCH:</p> <p>21 Q. You said before you read the</p> <p>22 paper that the -- Dr. Gunther and the other</p> <p>23 scientists who wrote it had some information</p> <p>24 that erionite was a possible contaminant in</p> <p>25 the soil in Mexico.</p>	<p>1 have a wide variety of mineral</p> <p>2 assemblages, but I don't know anything</p> <p>3 about mines specifically.</p> <p>4 QUESTIONS BY MR. FINCH:</p> <p>5 Q. Okay. Rocks that contain talc</p> <p>6 can have differing amounts of accessory</p> <p>7 minerals in the ore that the talc is mined</p> <p>8 from, correct?</p> <p>9 MR. CHACHKES: Objection.</p> <p>10 MR. FROST: Objection.</p> <p>11 THE WITNESS: Again, I only</p> <p>12 know in general terms where -- how</p> <p>13 talc is formed geologically. I know</p> <p>14 nothing about talc mines, so I can't</p> <p>15 answer any questions relating to talc</p> <p>16 occurrences in mines.</p> <p>17 QUESTIONS BY MR. FINCH:</p> <p>18 Q. Well, would you expect that the</p> <p>19 owners of the Johnson & Johnson mines in</p> <p>20 Vermont would have documented their</p> <p>21 understanding as to what material they were</p> <p>22 mining out of the ground over the course of</p> <p>23 the 35 years that the mines were operating?</p> <p>24 MR. FROST: Objection.</p> <p>25 THE WITNESS: As I said, I</p>
Page 163	Page 165
<p>1 And I'm just wondering how you</p> <p>2 came to that conclusion when I just showed</p> <p>3 you the paper before lunch.</p> <p>4 MR. CHACHKES: Objection.</p> <p>5 THE WITNESS: Well, I looked at</p> <p>6 that line that I just read, that the</p> <p>7 person had epithelial malignant</p> <p>8 pleural mesothelioma in a vehicle</p> <p>9 repairman. So -- and it says who was</p> <p>10 raised on a farm in the Mexican</p> <p>11 volcanic belt region. So I -- that's</p> <p>12 where I'm getting that conclusion.</p> <p>13 But as I said before, I'd have</p> <p>14 to read the paper to have -- to have</p> <p>15 any ability to answer your question in</p> <p>16 an accurate way.</p> <p>17 QUESTIONS BY MR. FINCH:</p> <p>18 Q. Okay. Would you agree that</p> <p>19 talc mines can have differing amounts of</p> <p>20 accessory minerals in the ore, in the talc</p> <p>21 ore, in the mine?</p> <p>22 MR. CHACHKES: Objection.</p> <p>23 THE WITNESS: I honestly don't</p> <p>24 know anything about talc mines. I do</p> <p>25 know that rocks that contain talc can</p>	<p>1 don't know anything about mine</p> <p>2 protocols or documentation. I have no</p> <p>3 knowledge of that, and I'd have to</p> <p>4 read up on it and research it to give</p> <p>5 you a good answer.</p> <p>6 QUESTIONS BY MR. FINCH:</p> <p>7 Q. Okay. You said you reviewed</p> <p>8 some of Dr. Longo's state court reports, in</p> <p>9 addition to his three reports in the MDL,</p> <p>10 correct?</p> <p>11 A. Yes. I skimmed them to look</p> <p>12 for more analytical data, and having found</p> <p>13 none, I didn't consider them further.</p> <p>14 Q. Okay. Did you see that in</p> <p>15 those reports, or in the disclosures that</p> <p>16 went with those reports, he had listed</p> <p>17 certain documents with Johnson & Johnson or</p> <p>18 Imerys Bates numbers on them that formed part</p> <p>19 of the basis of his knowledge in the state</p> <p>20 court cases?</p> <p>21 A. No, because as I just said, I</p> <p>22 only skimmed those documents to look for data</p> <p>23 that were relevant to my investigation, which</p> <p>24 was to evaluate the methodology used by them</p> <p>25 in the Longo and Rigler reports cited in my</p>

42 (Pages 162 to 165)

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 166</p> <p>1 report.</p> <p>2 Q. Okay. So to the extent that</p> <p>3 Dr. Longo, in various state court reports or</p> <p>4 in disclosures that you've been provided</p> <p>5 with, lists out Bates labels of Johnson &</p> <p>6 Johnson documents or Imerys documents, you</p> <p>7 didn't bother to review those; is that</p> <p>8 correct?</p> <p>9 MR. FROST: Objection.</p> <p>10 THE WITNESS: As I said, those</p> <p>11 documents were reviewed by me only</p> <p>12 with the goal of looking for further</p> <p>13 analytical data.</p> <p>14 But my goal in this undertaking</p> <p>15 is to evaluate methodology, and so I</p> <p>16 did not deem that that was relevant</p> <p>17 and, therefore, did not pursue the</p> <p>18 additional references in those</p> <p>19 reports.</p> <p>20 QUESTIONS BY MR. FINCH:</p> <p>21 Q. Is it your opinion that the</p> <p>22 entire universe of minerals that exists on</p> <p>23 the planet Earth can be found in the Vermont</p> <p>24 talc mines from which Johnson & Johnson</p> <p>25 obtained ore for baby powder?</p>	<p style="text-align: right;">Page 168</p> <p>1 scientist who was retained to analyze</p> <p>2 materials that come from a specific mine in a</p> <p>3 specific part of the world, one reasonable</p> <p>4 thing to do would be to read information</p> <p>5 about that geographic mine or that geographic</p> <p>6 source of the materials so that they have</p> <p>7 some understanding of what other researchers</p> <p>8 have found when they have investigated that</p> <p>9 particular mine?</p> <p>10 MR. CHACHKES: Objection.</p> <p>11 THE WITNESS: That's a really</p> <p>12 nebulous, hypothetical question. I</p> <p>13 was not hired to do that; I was hired</p> <p>14 to review methodology. So I don't</p> <p>15 have an opinion on that question</p> <p>16 because I haven't even thought about</p> <p>17 it.</p> <p>18 QUESTIONS BY MR. FINCH:</p> <p>19 Q. Have you ever been -- you have</p> <p>20 been hired, have you not, to analyze rocks</p> <p>21 and minerals found in outer space, on Mars or</p> <p>22 the moon, for example, to try to determine</p> <p>23 what they are, right?</p> <p>24 A. I am funded by both NASA and</p> <p>25 the National Science Foundation to study</p>
<p style="text-align: right;">Page 167</p> <p>1 MR. LOCKE: Objection.</p> <p>2 THE WITNESS: I have no</p> <p>3 knowledge of anything having to do</p> <p>4 with the geology of -- of the Vermont</p> <p>5 talc mines. So I would presume that</p> <p>6 because they are rocks, they contain</p> <p>7 minerals, but I know nothing about</p> <p>8 either the geology or the mineralogy</p> <p>9 of the Vermont talc mines.</p> <p>10 QUESTIONS BY MR. FINCH:</p> <p>11 Q. Your textbook was -- with</p> <p>12 Dr. Gunther was written for students, is that</p> <p>13 correct, graduate-level students?</p> <p>14 A. Actually it was written for</p> <p>15 undergraduate-level students, but we've sold</p> <p>16 a lot of copies of the book to people that</p> <p>17 don't do either of those things. We presume;</p> <p>18 we don't really know.</p> <p>19 Q. And the purpose of the book was</p> <p>20 in part to teach them how to analyze minerals</p> <p>21 to determine what they are?</p> <p>22 A. Yes, that's part of a standard</p> <p>23 mineralogy curriculum.</p> <p>24 Q. Would you agree with me that if</p> <p>25 you are a geologist who was -- or any</p>	<p style="text-align: right;">Page 169</p> <p>1 mineralogy of objects from all over the solar</p> <p>2 system, yes.</p> <p>3 Q. And as part of your background</p> <p>4 work in -- let's say you're given a grant to</p> <p>5 study minerals found on the moon.</p> <p>6 As part of your work, isn't it</p> <p>7 correct that you go and review the literature</p> <p>8 that exists about what other scientists have</p> <p>9 found in that environment that gives you some</p> <p>10 background understanding of what you might be</p> <p>11 looking for?</p> <p>12 MR. FROST: Objection.</p> <p>13 THE WITNESS: It depends on</p> <p>14 what I was -- what I was engaged to do</p> <p>15 or what I proposed to do. If I</p> <p>16 proposed to do a certain kind of</p> <p>17 analysis, yes, I would want to know</p> <p>18 who else had done analyses on that</p> <p>19 same material.</p> <p>20 But in this particular case</p> <p>21 here, I wasn't hired to do any</p> <p>22 testing, so I have no opinion on -- no</p> <p>23 interest in knowing what the rest of</p> <p>24 the literature says because I'm only</p> <p>25 evaluating methodology.</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 170</p> <p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. Dr. Longo was hired to test</p> <p>3 specific products and specific ores where the</p> <p>4 source of that material was ultimately talc</p> <p>5 mines in Vermont, Italy or China, correct?</p> <p>6 MR. CHACHKES: Objection.</p> <p>7 THE WITNESS: All I know is</p> <p>8 that the materials that are in this --</p> <p>9 that I reviewed in preparation of this</p> <p>10 report came from Asia, Vermont, and I</p> <p>11 don't remember where else.</p> <p>12 QUESTIONS BY MR. FINCH:</p> <p>13 Q. Italy?</p> <p>14 A. Italy.</p> <p>15 Q. And would you agree with me</p> <p>16 that it would be a reasonable thing for a</p> <p>17 scientist to do, who had been tasked with the</p> <p>18 job of analyzing the minerals in a product</p> <p>19 where the source of the primary ingredient of</p> <p>20 the product was a mine in a particular part</p> <p>21 of the world, to read studies that the people</p> <p>22 who owned the mine had done on the nature of</p> <p>23 the minerals that they were taking out of the</p> <p>24 ground?</p> <p>25 MR. LOCKE: Objection.</p>	<p style="text-align: right;">Page 172</p> <p>1 that.</p> <p>2 What you want to know is what's</p> <p>3 in the material based on the</p> <p>4 analytical methods that you're using,</p> <p>5 and that has nothing to do with where</p> <p>6 the material came.</p> <p>7 In fact, knowing where the</p> <p>8 material came from might bias a</p> <p>9 judgment, whereas unbiased judgment,</p> <p>10 which is what we want in science,</p> <p>11 would probably be most useful.</p> <p>12 (Dyar Exhibits 16 and 17 marked</p> <p>13 for identification.)</p> <p>14 QUESTIONS BY MR. FINCH:</p> <p>15 Q. Let's mark this as Exhibit 16</p> <p>16 and 17.</p> <p>17 Okay. I'm putting Exhibit 16</p> <p>18 and 17 in front of you and ask if you've ever</p> <p>19 seen them before.</p> <p>20 A. No, Exhibit 16, and no on</p> <p>21 Exhibit 17.</p> <p>22 Q. All right. Turn to page 2 of</p> <p>23 Exhibit 16.</p> <p>24 Did you have the understanding</p> <p>25 that in 1989 Johnson & Johnson sold the mines</p>
<p style="text-align: right;">Page 171</p> <p>1 THE WITNESS: No, I explicitly</p> <p>2 do not agree.</p> <p>3 The only thing that's relevant</p> <p>4 is the methodology and the data that</p> <p>5 were produced in the reports and</p> <p>6 whether or not the methodology is</p> <p>7 good, which it, of course, is not.</p> <p>8 So where the minerals came from</p> <p>9 is of no concern to whether -- to what</p> <p>10 the methods were that were used to</p> <p>11 analyze it. Those two things have</p> <p>12 nothing to do with each other.</p> <p>13 QUESTIONS BY MR. FINCH:</p> <p>14 Q. Would you agree with me that if</p> <p>15 you're doing a bulk analysis of a sample to</p> <p>16 determine whether or not it has asbestos in</p> <p>17 it or not, information about the manufacturer</p> <p>18 of that sample would be important information</p> <p>19 for Dr. Longo or any scientist to know before</p> <p>20 testing the material to determine whether and</p> <p>21 to what extent it had asbestos in it?</p> <p>22 MR. FROST: Objection.</p> <p>23 THE WITNESS: No, I do not</p> <p>24 agree. And in fact, I can't even</p> <p>25 understand why you would want to know</p>	<p style="text-align: right;">Page 173</p> <p>1 that it -- in Vermont that it got its talc</p> <p>2 from to a company called Cyprus?</p> <p>3 MR. FROST: Objection.</p> <p>4 THE WITNESS: I have no</p> <p>5 knowledge of that.</p> <p>6 QUESTIONS BY MR. FINCH:</p> <p>7 Q. And then ultimately, through a</p> <p>8 series of other transactions, ended up -- the</p> <p>9 mines are owned by Imerys?</p> <p>10 A. I have no knowledge of that.</p> <p>11 Q. On page 2 of Exhibit 16, the</p> <p>12 Cyprus employees who are writing this</p> <p>13 document write that "the other serious</p> <p>14 mineralogical contaminant in the talc ores of</p> <p>15 Vermont is the fibrous variety of the</p> <p>16 amphibole minerals, tremolite and actinolite,</p> <p>17 hydrous calcium, iron magnesium silicates,</p> <p>18 which have been classified as asbestiform</p> <p>19 minerals by OSHA and EPA. OSHA was suspected</p> <p>20 to declassify nonfibrous, blocky tremolite on</p> <p>21 February 29th but not -- has not as yet</p> <p>22 announced their decision. As a result, all</p> <p>23 tremolite, the fibrous varieties of all</p> <p>24 amphiboles and chrysotile asbestos in talc</p> <p>25 ores, are a source of great concern to all</p>

44 (Pages 170 to 173)

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 174</p> <p>1 talc producers and especially to the 2 marketers of cosmetic products. Cyprus 3 claims that there are no fibers in their 4 cosmetic talc products, and they work 5 rigorously to ensure this. However, a recent 6 paper published by Rutgers University worker 7 Alice Blount suggests the presence of fiber 8 in several cosmetic talcs, some of which 9 might have been from Cyprus West Windsor, 10 which is a source of great concern to Cyprus 11 management and potentially to their principal 12 customer, Johnson & Johnson. Talc de Luzenac 13 personnel are well aware of the situation, 14 and Phillippe Moreau is currently quietly 15 working to identify the reality and the 16 magnitude of the problem. 17 "Vermont talcs are derived from 18 altered serpentine, a natural host for 19 asbestiform minerals. There is certainly 20 visible tremolite and actinolite in specific 21 zones of Vermont deposits. Fibrous tremolite 22 was identified by the writer in exposures and 23 cores at the East Argonaut and Black Bear 24 mine. Cyprus staff report tremolite from the 25 Hammondsville and Clifton deposits."</p>	<p style="text-align: right;">Page 176</p> <p>1 information in this document for me to 2 be able to say anything. 3 QUESTIONS BY MR. FINCH: 4 Q. Okay. So you certainly can't 5 opine that this information contained in 6 Exhibit 16 is incorrect, can you, ma'am? 7 MR. FROST: Objection. 8 MR. CHACHKES: Objection. 9 THE WITNESS: Indeed, I can't 10 opine if it's correct either. I have 11 no opinion. 12 QUESTIONS BY MR. FINCH: 13 Q. Okay. 14 A. Because there is insufficient 15 context and information about this document. 16 For example, it says tremolite, 17 but there's no indication of really what kind 18 of tremolite it is. It confuses the 19 definition of fibers. 20 I would say there are a lot of 21 issues with this document that I would want 22 to know more about, so I can't really comment 23 about this document. 24 Q. Okay. Exhibit 17, do you have 25 that document?</p>
<p style="text-align: right;">Page 175</p> <p>1 MR. CHACHKES: Past. You 2 missed -- 3 MR. FINCH: Past tremolite from 4 the Hammondsville and Clifton 5 deposits. 6 QUESTIONS BY MR. FINCH: 7 Q. Do you see that? 8 A. I see that that's what the 9 document says, yes. 10 Q. Okay. And you have no 11 knowledge one way or another to suggest that 12 the authors of this memorandum are wrong in 13 their conclusions, correct? 14 MR. CHACHKES: Objection. 15 MR. LOCKE: Objection. 16 THE WITNESS: I do not have 17 enough information about this document 18 to render an opinion. 19 I see that it's an interoffice 20 correspondence. It talks about mines 21 in Vermont, but Vermont's a big state. 22 These deposits are presumably aerially 23 very large. I don't know if these 24 deposits were used for talc. 25 So there's just not enough</p>	<p style="text-align: right;">Page 177</p> <p>1 A. I do. 2 Q. This is analysis of fibrous 3 material from Argonaut waste rock? 4 A. Yes, I see that. 5 Q. Dated May 23, 2002? 6 A. Yes. That's what it says. 7 Q. Do you know who Julie Pier is? 8 A. No. 9 Q. You don't know that she's a 10 scientist for Luzenac America at the time 11 this memorandum was written? 12 MR. FROST: Objection. 13 THE WITNESS: I've never heard 14 of either Julie Pier or Luzenac. 15 QUESTIONS BY MR. FINCH: 16 Q. All right. On the second page 17 there is an SEM image and an EDS chemical 18 analysis of waste rock from the Argonaut 19 mine. 20 Do you see that? 21 A. Yes. 22 Q. All right. Do you agree with 23 me that the pictograph at the top, the 24 material looks like fibrous material and not 25 fragments?</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 178</p> <p>1 A. It's almost impossible to judge 2 that from a two-dimensional image, so I don't 3 really have any opinion on that. I don't 4 have an opinion. 5 I'd like to be able to measure 6 the population and do an analysis on it that 7 way to render an opinion. 8 Q. Would you agree with me that 9 a scientist using a scanning electron 10 microscope can, by moving the plates around, 11 look at the structure that he or she is 12 viewing in three dimensions and make a 13 determination whether morphologically and 14 visually it looks more like a fiber or a 15 bundle of fibers or a cleavage fragment? 16 MR. FROST: Objection. 17 THE WITNESS: No, I do not 18 agree with that statement. In fact, 19 the amount of tilt on the stage is 20 very small. There's no way you can 21 get a three-dimensional view of 22 something. 23 Only with a special kind of 24 polarizing light microscope can you 25 actually do a three-dimensional</p>	<p style="text-align: right;">Page 180</p> <p>1 Q. This is science being done for 2 commercial purposes, correct? 3 MR. FROST: Objection. 4 THE WITNESS: As I've stated, I 5 have no idea what Luzenac is. 6 QUESTIONS BY MR. FINCH: 7 Q. This was science being done not 8 for courtroom purposes? 9 A. I have no idea what the purpose 10 of this document is. I don't know anything 11 about the context. And it appears that there 12 is additional information that is not 13 included in the two pages that I've been 14 given, so it's hard to comment on this. I 15 can't even tell if this is the entire memo. 16 Q. Can you opine one way or 17 another about whether tremolite exists in 18 Vermont talc mines? 19 MR. CHACHKES: Objection. 20 THE WITNESS: No, I cannot. I 21 saw no evidence in any of the 22 Dr. Longo and Rigler reports that I 23 examined that supported a conclusion 24 of asbestos being present, and that's 25 the only data that I'm familiar with.</p>
<p style="text-align: right;">Page 179</p> <p>1 assessment in that manner. 2 QUESTIONS BY MR. FINCH: 3 Q. Do you see also that there's an 4 EDS chemical analysis below it? 5 A. I do. 6 Q. And the -- Dr. Pier concludes, 7 based on that, that the chemical analysis of 8 the material is consistent with tremolite? 9 MR. CHACHKES: Objection. 10 THE WITNESS: I see that that's 11 what this document concludes, yes. 12 QUESTIONS BY MR. FINCH: 13 Q. And the SEM, EDS analysis on 14 the second page of Exhibit 17 contains a 15 conclusion that the chemical composition of 16 the material is consistent with tremolite, 17 correct? 18 A. It says, "The chemical analysis 19 of the material above is consistent with 20 tremolite." Yes, that's what it says. 21 Q. And it doesn't have any of the 22 quantitative data found at the bottom of 23 Figure 7 in your report, correct? 24 A. That's correct. It looks to me 25 like another example of bad science.</p>	<p style="text-align: right;">Page 181</p> <p>1 Those are the only data I'm familiar 2 with. 3 QUESTIONS BY MR. FINCH: 4 Q. Can anthophyllite have varying 5 amounts of iron? 6 A. Yes. 7 Q. We haven't talked about another 8 way to analyze the chemical composition of 9 materials, X-ray diffraction or XRD. 10 Are you familiar with that? 11 A. Certainly. There's a chapter 12 if my book, and I teach that routinely. 13 Q. Would you agree with me that 14 what X-ray diffraction does, it allows you 15 to -- well, you tell me what X-ray 16 diffraction does, XRD. 17 A. X-ray diffraction is a superset 18 of what we've been talking about, SAED. It 19 uses diffraction of atoms in layers in a 20 mineral structure to indicate diagnostic 21 properties such as the spacing between the 22 atoms in the structure. 23 Q. Is X-ray diffraction a 24 sensitive-enough tool to find asbestos 25 contamination in material if it's less than</p>

<p style="text-align: right;">Page 182</p> <p>1 0.1 percent by weight of the material?</p> <p>2 MR. FROST: Objection.</p> <p>3 THE WITNESS: So I believe if</p> <p>4 you look at the ISO 22262-1, it</p> <p>5 explains that in fact it is difficult</p> <p>6 to measure abundances of small</p> <p>7 materials at those levels with X-ray</p> <p>8 diffraction.</p> <p>9 QUESTIONS BY MR. FINCH:</p> <p>10 Q. Would X-ray diffraction allow</p> <p>11 you to determine whether or not there is</p> <p>12 fibrous talc in a sample of talc that you</p> <p>13 were testing?</p> <p>14 A. Absolutely not.</p> <p>15 MR. LOCKE: Objection.</p> <p>16 THE WITNESS: Because X-ray</p> <p>17 diffraction uses the arrangement of</p> <p>18 atoms in the crystal structure, which</p> <p>19 at best only tells you which mineral</p> <p>20 species it is. But X-ray diffraction</p> <p>21 cannot determine anything about the</p> <p>22 morphology of particular particles.</p> <p>23 QUESTIONS BY MR. FINCH:</p> <p>24 Q. Would you agree that talc can</p> <p>25 be fibrous?</p>	<p style="text-align: right;">Page 184</p> <p>1 Q. And aspect ratio just is the</p> <p>2 ratio of length to width; is that correct?</p> <p>3 A. That's correct.</p> <p>4 But it's possible to have</p> <p>5 morphologies that have nothing to do with</p> <p>6 dimensions.</p> <p>7 Q. How so?</p> <p>8 A. For example, minerals form</p> <p>9 as -- in rose shapes with petals, so that's a</p> <p>10 specific morphology.</p> <p>11 Q. Would you agree with me that</p> <p>12 minerals can form in bundles?</p> <p>13 A. Bundles is not a term we</p> <p>14 generally use to identify minerals. For</p> <p>15 example, I don't believe we even discuss the</p> <p>16 term "bundle" in the chapter of our book</p> <p>17 where we talk about the physical</p> <p>18 characteristics of minerals.</p> <p>19 On the other hand, in my report</p> <p>20 I show a photograph of a -- of a -- excuse</p> <p>21 me, of a bundle, so indeed I'm aware that</p> <p>22 some minerals can form as bundles.</p> <p>23 Q. Do you agree with me that</p> <p>24 asbestos fibers can form as bundles?</p> <p>25 A. Well, given that there's a</p>
<p style="text-align: right;">Page 183</p> <p>1 A. I have no knowledge of that</p> <p>2 because I haven't studied that.</p> <p>3 Q. But whether talc is -- can be</p> <p>4 fibrous or not, you wouldn't -- X-ray</p> <p>5 diffraction would not be able to tell you</p> <p>6 whether there was fibrous talc in a sample of</p> <p>7 talc, correct?</p> <p>8 A. Correct. X-ray diffraction</p> <p>9 cannot determine the morphology of a</p> <p>10 particle. Only confirm the crystal</p> <p>11 structure.</p> <p>12 Q. You just used the word</p> <p>13 "morphology" in a sentence.</p> <p>14 Can you define how you used</p> <p>15 morphology in that sentence?</p> <p>16 A. I meant the shape, aspect</p> <p>17 ratio. It's a...</p> <p>18 Q. So morphology can mean shape</p> <p>19 and aspect ratio?</p> <p>20 A. Well, I was saying as -- for</p> <p>21 example, as evidenced by aspect ratio, is</p> <p>22 what I meant to say.</p> <p>23 Q. Okay. As evidenced by aspect</p> <p>24 ratio?</p> <p>25 A. Correct.</p>	<p style="text-align: right;">Page 185</p> <p>1 picture of a -- here we go. It's</p> <p>2 Figure 23 B. It's an image of a tremolite</p> <p>3 bundle of asbestiform particles from a paper</p> <p>4 by Harper, et al.</p> <p>5 So, yes, given that this image</p> <p>6 exists, and to the extent that Harper asserts</p> <p>7 that they can form as bundles, then, yes,</p> <p>8 indeed, tremolite can form as an asbestiform</p> <p>9 bundle.</p> <p>10 Q. And can anthophyllite form as</p> <p>11 an asbestiform bundle?</p> <p>12 A. I have personally not seen</p> <p>13 either an image or a -- with my own eyes, an</p> <p>14 anthophyllite bundle, so I really can't</p> <p>15 answer that question either way.</p> <p>16 Q. So morphology refers to the</p> <p>17 shape as measured by aspect ratio and --</p> <p>18 A. As measured, for example, by --</p> <p>19 Q. As measured, for example, by</p> <p>20 the aspect ratio and the nature in which the</p> <p>21 material can be found, whether it's</p> <p>22 rose-petal-shaped or a bundle or a fragment</p> <p>23 or something else, right?</p> <p>24 A. Correct.</p> <p>25 Q. And those are -- the way you</p>

Melinda Darby Dyar, Ph.D.

Page 186	Page 188
<p>1 would analyze that in a laboratory is you 2 would take a photomicrograph of it using 3 either a PLM or a electron microscope, 4 scanning or transmission, and take 5 measurements of the structure that you're 6 observing to determine what its aspect ratio 7 is, how thick it is, how long it is, and what 8 it looks like visually, like exhibit -- 9 excuse me, Figure 23 C that you referred me 10 to before. 11 MR. CHACHKES: Objection. 12 QUESTIONS BY MR. FINCH: 13 Q. Correct? 14 A. I referred you to 23 B before. 15 Q. Excuse me, 23 B as in boy. 16 A. So I got to look at your 17 question. 18 It -- actually, can you restate 19 the question as a question? 20 Q. Sure. 21 Morphology, I'm trying to get 22 the universe of the stuff that goes into the 23 analysis of morphology. 24 It is the shape as, for 25 example, measured by aspect ratio, the size,</p>	<p>1 image or individual crystal. 2 Q. Okay. So if you have an 3 individual image that is 10 microns long, you 4 can't make a conclusive diagnosis or 5 determination as to whether or not based on 6 morphology it is asbestiform or 7 non-asbestiform, correct? 8 MR. FROST: Objection. 9 THE WITNESS: You cannot 10 determine anything from an individual 11 image. You need a population to be 12 able to make a determination. 13 QUESTIONS BY MR. FINCH: 14 Q. Okay. And how many fibers 15 consist of a population or images, 16 structures? 17 A. Statistically, that's a 18 difficult answer -- that's a difficult 19 question to answer. It would depend on the 20 context and the problem at hand. 21 Q. Is there any generally accepted 22 standard that you could point me to that says 23 in order to do a statistical analysis of a 24 population you need a minimum of X structures 25 or fibers to analyze?</p>
Page 187	Page 189
<p>1 the appearance, and the form in which it is 2 found, as exemplified by either a bundle or a 3 rose petal shape. 4 Are those all the aspects of 5 morphology as it relates to asbestos 6 minerals? 7 MR. FROST: Objection. 8 THE WITNESS: The only aspect 9 of morphology that applies -- that is 10 relevant to this identification of 11 asbestiform minerals is whether or not 12 the population of shapes expressed as 13 width versus length or aspect ratio 14 belongs to the population of 15 asbestiform or non-asbestiform 16 minerals. That is the only aspect of 17 morphology that's relevant to this 18 particular inquiry. 19 QUESTIONS BY MR. FINCH: 20 Q. Okay. And that population of 21 shapes, that is a statistical analysis you do 22 if you have enough structures to analyze for 23 purposes of aspect ratio, correct? 24 A. Correct. You cannot make a 25 firm diagnosis on the basis of an individual</p>	<p>1 A. I would want to go back and 2 look at some of the papers that I cited where 3 we talk about looking at populations. For 4 example, the R-93 document talks about 5 populations. One of these ISO documents 6 talks about populations. But I do not recall 7 specifically any of them having a number of 8 samples that you'd have to analyze. 9 We talk about this in my 10 statistics book. The number of samples that 11 you need for any given scenario is extremely 12 variable. 13 Q. So sitting here right now, 14 which is my one chance to take your 15 deposition before the Daubert hearing, you 16 don't know of any generally accepted or 17 relied upon standard which has a minimum 18 number of fibers or structures you need to 19 analyze in order to analyze the aspect ratios 20 to determine whether it's asbestiform or 21 non-asbestiform? 22 MR. FROST: Objection. 23 MR. LOCKE: Objection. 24 THE WITNESS: I would say you 25 need enough fibers to create a</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 190</p> <p>1 distribution with an acceptable 2 standard deviation on the mean. 3 QUESTIONS BY MR. FINCH: 4 Q. Is 100 fibers or structures 5 sufficient to do that? 6 A. I think that's -- that's 7 subjective and it depends -- you know, it 8 depends on the particular profile of the 9 population. And it also depends on the 10 confidence with which you want to be able to 11 state your opinions or your conclusions. 12 Q. All right. At page 18, 13 footnote 34. 14 A. Page 18 of my report? 15 Q. Yes, page 18, footnote 34. 16 A. Uh-huh. 17 Q. You say, "The EDS results in 18 the Longo, Rigler MDL reports labeled as 19 tremolite may very well be consistent with 20 minerals other than diopside." 21 Do you know if diopside has 22 ever been found in any of the mines in 23 Vermont that Johnson & Johnson obtained talc 24 from? 25 A. No, I don't know anything about</p>	<p style="text-align: right;">Page 192</p> <p>1 talc mines. 2 QUESTIONS BY MR. FINCH: 3 Q. Do you know where in the world 4 bredigite is found? 5 A. No. 6 Q. Merwinite? 7 A. No. 8 Q. Rondorfite? 9 A. No. 10 Q. You don't know if any of those 11 minerals were ever found in any analysis 12 anyone's ever done of talc from Vermont used 13 by Johnson & Johnson, correct? 14 A. I believe I've made it clear 15 that I know nothing about the mineralogy of 16 any of the rocks in Vermont. 17 Q. Or that would go for Italy and 18 China as well? You know nothing about the 19 mineralogy of the talc mines Johnson & 20 Johnson sourced its talc from Italy or China? 21 A. That's correct. 22 May I add that although those 23 minerals are very rare, I continue in my 24 footnote to say many more common minerals 25 would be included in this list if iron and</p>
<p style="text-align: right;">Page 191</p> <p>1 the mineral assemblages present anywhere in 2 Vermont. 3 Q. You go on to say, "Dr. Longo 4 and Rigler might have never produced their 5 quantitative data and, accordingly, this 6 analysis cannot be completed, drop footnote 7 34. 8 "For example, these may include 9 at least monticellite, bredigite, merwinite 10 and rondorfite, which are other minerals that 11 contain only silicone, magnesium and 12 calcium." 13 A. That's what I say. 14 Q. All right. Do you know if -- 15 where in the world monticellite is found? 16 A. Actually, monticellite is found 17 in New York. I've collected it in the 18 Adirondacks just across the river from 19 Vermont. 20 Q. Do you know if it's ever been 21 found in any of the mines in Vermont that 22 Johnson & Johnson obtained its talc from? 23 MR. CHACHKES: Objection. 24 THE WITNESS: I know nothing 25 about the mineralogy of the Vermont</p>	<p style="text-align: right;">Page 193</p> <p>1 sodium were allowed. 2 So I specifically created this 3 example to be simple, but, in fact, in nature 4 there would be many, many minerals that would 5 be easily confused with tremolite on the 6 basis of an EDS analysis. 7 Q. All right. We were talking 8 about morphology a little while ago. 9 That's one way -- one analysis 10 that a scientist does to determine whether or 11 not material he or she is analyzing is 12 asbestos or not, right? It's one of the 13 pieces of the puzzle? 14 A. So, indeed, the criterion to be 15 lengthwise separable into flexible fibers 16 with high tensile strength and flexibility is 17 the definition of asbestos, then, yes, the 18 assessment of whether something is that sort 19 of fiber is relevant, yes. 20 Q. And one of the analyses that 21 goes into that is analysis of aspect ratios, 22 correct? 23 A. Aspect ratios are one way of 24 making that assessment, yes. 25 Q. Okay. And another analysis</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 194</p> <p>1 that a scientist can and should do to</p> <p>2 determine whether or not the material he is</p> <p>3 analyzing is asbestos or not is an analysis</p> <p>4 of its chemical composition, correct?</p> <p>5 A. So the definition of asbestos</p> <p>6 includes chemical composition, crystal</p> <p>7 structure and lengthwise separable into</p> <p>8 flexible fibers with high tensile strength.</p> <p>9 So to the extent that chemical</p> <p>10 composition is part of identifying a specific</p> <p>11 mineral species, then, yes, it's relevant.</p> <p>12 Q. Amosite is one of the</p> <p>13 well-accepted amphibole minerals that can be</p> <p>14 asbestiform?</p> <p>15 A. That is one of the six minerals</p> <p>16 that's listed in the many lists in this</p> <p>17 document, yes.</p> <p>18 Q. Do you know whether amosite can</p> <p>19 split both horizontally as well as</p> <p>20 longitudinally?</p> <p>21 MR. FROST: Objection.</p> <p>22 THE WITNESS: I have no</p> <p>23 explicit knowledge of amosite. There</p> <p>24 was no mention of amosite in the Longo</p> <p>25 and Rigler documents that I was asked</p>	<p style="text-align: right;">Page 196</p> <p>1 Q. And SAED is performed with</p> <p>2 either a transmission electron microscope or</p> <p>3 a SEM microscope?</p> <p>4 A. Generally, yes.</p> <p>5 Q. And the analyst has the</p> <p>6 structure or bundle on the grid, or on</p> <p>7 multiple grids, and is able to rotate it and</p> <p>8 look at the SAED -- look at the crystalline</p> <p>9 structure by SAED from different angles or</p> <p>10 viewpoints, correct?</p> <p>11 A. Sort of.</p> <p>12 Q. What's a goniometer?</p> <p>13 A. So a goniometer is something</p> <p>14 that allows you to swivel something in</p> <p>15 three-dimensional space. But on a TEM, the</p> <p>16 space constraints are such that you can only</p> <p>17 swivel it a very small amount.</p> <p>18 Q. Does polarized light microscopy</p> <p>19 allow you to determine whether or not a</p> <p>20 structure or a fiber is asbestos or not?</p> <p>21 A. PLM allows you to determine the</p> <p>22 refractive index of a material, and it allows</p> <p>23 you to say something about the dimensions of</p> <p>24 an individual particle. But it tells you</p> <p>25 nothing about the population distribution</p>
<p style="text-align: right;">Page 195</p> <p>1 to review, and, therefore, I have no</p> <p>2 opinion on that because I have not</p> <p>3 investigated that question.</p> <p>4 QUESTIONS BY MR. FINCH:</p> <p>5 Q. The way one determines the</p> <p>6 chemical composition of a fiber or structure</p> <p>7 that one expects to potentially be asbestos</p> <p>8 is using EDS, EDXA, correct?</p> <p>9 A. So as I explained in my report,</p> <p>10 EDS and EDXA are the only analytical --</p> <p>11 geo-analytical techniques that are high</p> <p>12 enough in resolution to be able to say</p> <p>13 anything about the chemical composition of a</p> <p>14 very tiny particle.</p> <p>15 Q. And that is a qualitative</p> <p>16 analysis that is semi-quantitative at best,</p> <p>17 correct?</p> <p>18 A. Correct.</p> <p>19 Q. A third step that a scientist</p> <p>20 should undertake to determine whether or not</p> <p>21 a particle or structure that he or she is</p> <p>22 analyzing is asbestos is to analyze its</p> <p>23 crystalline structure, correct?</p> <p>24 A. Using a technique such as SAED,</p> <p>25 yes.</p>	<p style="text-align: right;">Page 197</p> <p>1 and, therefore, couldn't tell you anything</p> <p>2 about whether or not it was asbestiform or</p> <p>3 non-asbestiform.</p> <p>4 Q. But if you have a sample of</p> <p>5 material and you combine all four different</p> <p>6 analysis - morphology, the chemical</p> <p>7 composition analysis using EDS, EDXA, the</p> <p>8 crystal structure analysis using SAED, and a</p> <p>9 polarized light microscope analysis of the</p> <p>10 material, the same -- the sample - would that</p> <p>11 give you a high level of confidence that what</p> <p>12 you were looking at was asbestos if it was</p> <p>13 consistent with the regulated asbestos</p> <p>14 materials as measured by morphology, chemical</p> <p>15 composition, crystal structure and refractive</p> <p>16 index?</p> <p>17 MR. CHACHKES: Objection.</p> <p>18 THE WITNESS: Well, that's</p> <p>19 quite a mouthful of a sentence.</p> <p>20 Boy. If done correctly. But,</p> <p>21 of course, the methodology used in the</p> <p>22 Longo, Rigler report was not done</p> <p>23 correctly.</p> <p>24 For example, you say SAED.</p> <p>25 Well, a single SAED analysis is not</p>

Melinda Darby Dyar, Ph.D.

Page 198	Page 200
<p>1 enough to identify a mineral. So if</p> <p>2 you only had one SAED, then you</p> <p>3 couldn't identify asbestos, et cetera,</p> <p>4 et cetera.</p> <p>5 If you only had one measurement</p> <p>6 of the dimensions of the particle, you</p> <p>7 wouldn't know anything about the</p> <p>8 population from which it was drawn</p> <p>9 and, therefore, you could not</p> <p>10 determine if it came -- if it was</p> <p>11 asbestos.</p> <p>12 So that's a general --</p> <p>13 generalized question that is</p> <p>14 impossible to answer. But I can</p> <p>15 certainly say that with the individual</p> <p>16 measurements -- or with the methods</p> <p>17 used in the -- used by Drs. Longo and</p> <p>18 Rigler, no, you cannot determine if</p> <p>19 something is asbestos.</p> <p>20 Moreover, I will also say that</p> <p>21 each of those techniques perhaps</p> <p>22 identifies maybe 250 to 500 different</p> <p>23 possible minerals -- I'm just making</p> <p>24 those numbers up -- and they're the</p> <p>25 same 250 to 500 minerals because they</p>	<p>1 having only two dimensions is not diagnostic,</p> <p>2 which is the point of the data I present in</p> <p>3 this report to show that there are many, many</p> <p>4 minerals that satisfy the D spacing criteria</p> <p>5 that Dr. Longo uses.</p> <p>6 Q. All right. The D spacing is</p> <p>7 the space -- the distance between the atoms,</p> <p>8 correct?</p> <p>9 A. Distance between layers of</p> <p>10 atoms, yes.</p> <p>11 Q. And the zone axis measurement</p> <p>12 is the measurement of the angles?</p> <p>13 A. The zone axis measurement just</p> <p>14 refers to the way the crystal was positioned</p> <p>15 at the time the X-ray pattern was collected</p> <p>16 relative to the crystal structure itself.</p> <p>17 Q. And you -- and you say that the</p> <p>18 Yamate 3 methodology for confirming the</p> <p>19 presence of asbestos in talc requires two</p> <p>20 SAED zone axis determination and an EDS</p> <p>21 analysis, correct?</p> <p>22 A. That's what the Yamate</p> <p>23 statement says. And if you'd like, we can</p> <p>24 take a look at that together.</p> <p>25 Q. Well, we'll get to there in a</p>
Page 199	Page 201
<p>1 all have very similar compositions,</p> <p>2 crystal structures, et cetera, et</p> <p>3 cetera.</p> <p>4 So this methodology is</p> <p>5 fundamentally flawed.</p> <p>6 QUESTIONS BY MR. FINCH:</p> <p>7 Q. Are you saying the -- let me</p> <p>8 focus on the SAED.</p> <p>9 What's the basis for your</p> <p>10 statement in your report at page 29 and 40</p> <p>11 that --</p> <p>12 A. You mean 29 and 30?</p> <p>13 Q. 29 and 40. You say it in two</p> <p>14 different places.</p> <p>15 A. Oh.</p> <p>16 Q. You cite to Yamate for the</p> <p>17 proposition that SAED requires at least two</p> <p>18 zone axes in order to make a determination of</p> <p>19 the crystalline structure.</p> <p>20 A. Yes, that's correct.</p> <p>21 Q. What's the basis for that</p> <p>22 statement?</p> <p>23 A. One SAED pattern only tells you</p> <p>24 two dimensions of what is a three-dimensional</p> <p>25 crystal structure lattice. As it happens,</p>	<p>1 minute.</p> <p>2 Other than Yamate, 1984, can</p> <p>3 you point me to any generally recognized</p> <p>4 standard or peer-reviewed literature that</p> <p>5 says that you have to have two SAED zone axis</p> <p>6 determinations for every particle that one is</p> <p>7 analyzing using SAED?</p> <p>8 A. So I would imagine that every</p> <p>9 mineralogy book ever written about</p> <p>10 crystallography explains that minerals are</p> <p>11 three-dimensional structures, and it's always</p> <p>12 necessary to know all three directions in</p> <p>13 order to identify a mineral.</p> <p>14 Books that come to mind include</p> <p>15 probably the Hurlbut and Klein textbook that</p> <p>16 you already have, Bloss' optical</p> <p>17 crystallography book, certainly my book.</p> <p>18 And many other sources would</p> <p>19 tell you that just because a mineral has one</p> <p>20 particular dimension, which is basically what</p> <p>21 Dr. Longo provides in the diffraction</p> <p>22 verification document, no conclusions can be</p> <p>23 drawn regarding identification.</p> <p>24 Q. With respect to asbestos</p> <p>25 specifically, can you identify anything</p>

51 (Pages 198 to 201)

Melinda Darby Dyar, Ph.D.

Page 202	Page 204
<p>1 besides Yamate that states that you need two</p> <p>2 SAED zone axis determinations in order to --</p> <p>3 and an EDS analysis in order to make a</p> <p>4 determination that a material is asbestos?</p> <p>5 MR. FROST: Objection.</p> <p>6 THE WITNESS: I'm sure I could</p> <p>7 find some citations. It's such a</p> <p>8 common, obvious thing that I don't</p> <p>9 think anyone would write a</p> <p>10 peer-reviewed paper to even say that.</p> <p>11 QUESTIONS BY MR. FINCH:</p> <p>12 Q. You haven't listed anything</p> <p>13 other than Yamate in your report; is that</p> <p>14 correct?</p> <p>15 A. To support this particular</p> <p>16 point, no, because it's common knowledge</p> <p>17 among crystallographers.</p> <p>18 Q. All right. You have Yamate. I</p> <p>19 think it's Exhibit --</p> <p>20 A. 7.</p> <p>21 Q. 7.</p> <p>22 You were quoting from page 44?</p> <p>23 A. Uh-huh.</p> <p>24 Q. "The protocol states that the</p> <p>25 identification requires two SAED zone axis</p>	<p>1 near exact zone orientations be done for</p> <p>2 every structure that one is looking at?</p> <p>3 A. That's what it says.</p> <p>4 Q. Could you turn to the next</p> <p>5 page?</p> <p>6 A. It says "from each selected</p> <p>7 fiber."</p> <p>8 Q. Turn to the next page in</p> <p>9 Yamate.</p> <p>10 A. (Witness complies.)</p> <p>11 Q. Under point 5 it says, "It is</p> <p>12 recommended that approximately 20 percent, at</p> <p>13 least 10 percent of the fibers examined in</p> <p>14 level 2 analysis, be selected for level 3</p> <p>15 SAD -- SAED analysis. Fibers which would be</p> <p>16 classified as amphiboles are ambiguous in</p> <p>17 level 2 analysis should be more often</p> <p>18 included for level 3 analysis as compared to</p> <p>19 those fibers which could readily be</p> <p>20 identified as not asbestos."</p> <p>21 Do you see that?</p> <p>22 A. I see that.</p> <p>23 So let's take this back to</p> <p>24 what's actually in the Longo, Rigler reports.</p> <p>25 So in point of fact, there are</p>
Page 203	Page 205
<p>1 determinations and an EDS analysis."</p> <p>2 You're referring to the -- I'm</p> <p>3 on page 41. You're referring to the Yamate</p> <p>4 protocol, right?</p> <p>5 A. Oh, wait a minute. Are we</p> <p>6 talking about my report now?</p> <p>7 Q. I'm looking at your report,</p> <p>8 page 41, and it says, "The protocol,"</p> <p>9 referring to Yamate, "states that</p> <p>10 identification requires two SAED zone axis</p> <p>11 determinations."</p> <p>12 A. Yes, that's what it says.</p> <p>13 Q. Okay. And where does it say</p> <p>14 that in Yamate?</p> <p>15 A. Oh, let's take a look here.</p> <p>16 On page 44 it says, "The level</p> <p>17 3 analytical procedure consists of locating</p> <p>18 the selected fibers," blah-blah-blah,</p> <p>19 "obtaining and according two zone axis SAED</p> <p>20 patterns from each selected fiber, and</p> <p>21 obtaining, recording and photographing</p> <p>22 representative EDS spectra from the subject</p> <p>23 fiber."</p> <p>24 Q. Okay. Does the Yamate criteria</p> <p>25 require that SAED analysis from two different</p>	<p>1 no individual fibers for which two SAED</p> <p>2 patterns are given. And in fact, only after</p> <p>3 the fact were any diffraction verification</p> <p>4 documents given, and I don't believe that</p> <p>5 they represent even 20 percent of the</p> <p>6 particles identified by Drs. Longo and</p> <p>7 Rigler. So their methodology is flawed on</p> <p>8 many counts relating to this.</p> <p>9 Q. Isn't it true that the SAED</p> <p>10 diffraction verification documents that Longo</p> <p>11 and Rigler provided consist of more than</p> <p>12 10 percent of the total number of structures</p> <p>13 they analyzed?</p> <p>14 A. I believe they only looked at</p> <p>15 six out of the 70-odd samples that they</p> <p>16 studied, so six out of 70-odd is not quite</p> <p>17 10 percent. I don't have the exact numbers</p> <p>18 in my head.</p> <p>19 Q. ISO 22262-1 is a publication</p> <p>20 that you at least cite to and rely on in your</p> <p>21 discussion of Dr. Rigler and Dr. Longo's</p> <p>22 work, correct?</p> <p>23 MR. FROST: Objection.</p> <p>24 THE WITNESS: I certainly point</p> <p>25 out where their methodology is</p>

Melinda Darby Dyar, Ph.D.

Page 206	Page 208
<p>1 consistent and inconsistent with</p> <p>2 what's in this report, yes.</p> <p>3 QUESTIONS BY MR. FINCH:</p> <p>4 Q. Could you turn to page 64 of</p> <p>5 what's been marked as Exhibit 4, ISO 22262-1?</p> <p>6 A. Section F 3?</p> <p>7 Q. Yes.</p> <p>8 What is it talking about in</p> <p>9 section F 3?</p> <p>10 A. Electron diffraction.</p> <p>11 Q. Is that another name for SAED?</p> <p>12 A. In this context, yes.</p> <p>13 Q. Okay. One, two, three, four,</p> <p>14 five paragraphs down --</p> <p>15 A. Uh-huh.</p> <p>16 Q. -- ISO 22262-1 states, "ED,"</p> <p>17 referring to electron diffraction patterns,</p> <p>18 "can be particularly useful for</p> <p>19 differentiating fibrous talc from</p> <p>20 anthophyllite asbestos, both of which have</p> <p>21 similar EDXA spectra."</p> <p>22 First of all, do you agree that</p> <p>23 fibrous talc and anthophyllite asbestos have</p> <p>24 similar EDXA spectra?</p> <p>25 A. I agree that talc and</p>	<p>1 amounted in the appropriate holder" --</p> <p>2 MR. CHACHKES: Mounted.</p> <p>3 QUESTIONS BY MR. FINCH:</p> <p>4 Q. -- "mounted in the appropriate</p> <p>5 holder."</p> <p>6 And then it goes on to describe</p> <p>7 the complete rotation of the specimen grid</p> <p>8 and the tilting of the grid about a single</p> <p>9 axis.</p> <p>10 Do you see that?</p> <p>11 A. Yes.</p> <p>12 Q. And it instructs the analyst to</p> <p>13 tilt the fiber until an ED pattern appears,</p> <p>14 which is a symmetrical, two-dimensional --</p> <p>15 which is a symmet -- two words, a, space,</p> <p>16 symmetrical, two-dimensional array of spots.</p> <p>17 The recognition of zone axis alignment</p> <p>18 conditions require some experience on the</p> <p>19 part of the operator.</p> <p>20 Do you agree with that?</p> <p>21 A. Yes. Although we teach</p> <p>22 students to do that.</p> <p>23 Q. And you agree with me that</p> <p>24 what's going on here is the analyst is</p> <p>25 tilting the structure around in realtime,</p>
Page 207	Page 209
<p>1 anthophyllite have similar EDS spectra</p> <p>2 because, of course, that's all you can say</p> <p>3 about those methods. They only look at</p> <p>4 chemistry. So all I can say is that</p> <p>5 chemically, talc and anthophyllite can be</p> <p>6 quite similar.</p> <p>7 Q. Then going on to, "Electron</p> <p>8 diffraction of talc produces a pseudo</p> <p>9 hexagonal pattern that does not change as the</p> <p>10 fiber is tilted using the goniometer.</p> <p>11 Anthophyllite asbestos, on the other hand,</p> <p>12 produces assorted spots appearing and</p> <p>13 disappearing along layer lines as the fiber</p> <p>14 is tilted using the goniometer."</p> <p>15 That refers to the analyst</p> <p>16 looking at the sample in the transmission</p> <p>17 electron microscope and tilting it, correct?</p> <p>18 A. That's what it refers to, yes.</p> <p>19 Q. All right. The next two</p> <p>20 sentences deal with chrysotile, so I'm going</p> <p>21 to skip those.</p> <p>22 "Analysis of laboratory samples</p> <p>23 seldom requires zone axis measurements.</p> <p>24 However, if a zone axis ED analysis is to be</p> <p>25 attempted on the fiber, the sample should be</p>	<p>1 looking at it through the transmission</p> <p>2 electron microscope to look -- to see whether</p> <p>3 or not when he or she adjusts the goniometer</p> <p>4 that the -- whether or not the hexagonal</p> <p>5 pattern changes or not?</p> <p>6 A. Sort of.</p> <p>7 What's going on is that you're</p> <p>8 trying to tilt the sample so that rows of</p> <p>9 atoms in the sample are perpendicular to the</p> <p>10 beam of electrons. That's what you're doing.</p> <p>11 And that satisfies the</p> <p>12 diffraction condition and, therefore, gives a</p> <p>13 pattern of spots.</p> <p>14 Q. All right. On page 65 --</p> <p>15 A. Uh-huh.</p> <p>16 Q. -- the standard states, "If the</p> <p>17 results obtained from one ED pattern do not</p> <p>18 resolve any ambiguity in the identification</p> <p>19 of a fiber, a second ED pattern obtained at a</p> <p>20 different orientation of the fiber can be</p> <p>21 examined, and the observed tilt angle between</p> <p>22 the two orientations can be compared with the</p> <p>23 theoretical angle calculated from the</p> <p>24 suspected crystal structure."</p> <p>25 Do you see that?</p>

Melinda Darby Dyar, Ph.D.

Page 210	Page 212
<p>1 A. Actually, I don't see where</p> <p>2 that is, but --</p> <p>3 Q. Page 65.</p> <p>4 A. Yeah, I'm looking at it.</p> <p>5 Q. Bottom paragraph.</p> <p>6 A. Oh, at the bottom. Yes. Okay.</p> <p>7 Q. All right.</p> <p>8 A. Where it's talking about using</p> <p>9 a computer program to do this, yes.</p> <p>10 Q. What it says is, "If the</p> <p>11 results obtained from one ED pattern do not</p> <p>12 resolve any ambiguity in the identification</p> <p>13 of a fiber, a second ED pattern obtained at a</p> <p>14 different orientation of the fiber can be</p> <p>15 examined."</p> <p>16 Would you agree with me that</p> <p>17 "can" does not say "shall" or "must"?</p> <p>18 A. I agree with you that it says</p> <p>19 "can," but I believe you're proving the point</p> <p>20 I made in my report, which is that crystal</p> <p>21 structures are inherently three-dimensional,</p> <p>22 and you cannot identify a specific mineral</p> <p>23 species on the basis of only one orientation.</p> <p>24 Q. But how do you -- what's --</p> <p>25 what is the basis for your conclusion that</p>	<p>1 that ISO 22262-1 at page 64 says that at</p> <p>2 least when you're examining anthophyllite</p> <p>3 asbestos versus talc, it becomes apparent by</p> <p>4 tilting the goniometer which is which because</p> <p>5 the image does not change if it's talc, if</p> <p>6 the fiber is tilted?</p> <p>7 MR. LOCKE: Objection.</p> <p>8 THE WITNESS: So let's</p> <p>9 decompose that question a little bit.</p> <p>10 First of all, it is true that</p> <p>11 at specific orientations the</p> <p>12 diffraction patterns of talc and</p> <p>13 anthophyllite can look quite similar.</p> <p>14 It is also true that if you</p> <p>15 tilt the stage, you may not see the</p> <p>16 same pattern of spots for talc and</p> <p>17 anthophyllite.</p> <p>18 But it all goes back to the</p> <p>19 point I make in my report, which is</p> <p>20 that if you only have one of these</p> <p>21 patterns, it doesn't matter how hard</p> <p>22 you work to get it, one pattern is not</p> <p>23 enough to identify a three-dimensional</p> <p>24 structure, because one pattern can</p> <p>25 only physically tell you about two</p>
Page 211	Page 213
<p>1 the analysts that were looking at the</p> <p>2 crystalline structure in realtime using SEM</p> <p>3 in Dr. Longo's lab were not turning the</p> <p>4 goniometer to look at it from multiple</p> <p>5 perspectives?</p> <p>6 Do you have any basis for</p> <p>7 concluding that they weren't doing that?</p> <p>8 A. My basis for concluding that is</p> <p>9 that they only include one image for each</p> <p>10 crystal. Therefore, there is no evidence in</p> <p>11 any of their reports that they did multiple</p> <p>12 zone axis measurements.</p> <p>13 Q. So what you're saying is</p> <p>14 because there's not more than one image, that</p> <p>15 means that they didn't look at it from two</p> <p>16 different angles, as ISO 22262-1 discusses at</p> <p>17 page 64?</p> <p>18 A. Precisely. And that is the</p> <p>19 point I make in my report, that they do not</p> <p>20 look at more than one zone axis on any</p> <p>21 individual crystal.</p> <p>22 Q. Well, you're just assuming</p> <p>23 that, aren't you? They just -- they didn't</p> <p>24 take a picture of a different zone axis.</p> <p>25 But wouldn't you agree with me</p>	<p>1 dimensions.</p> <p>2 MR. CHACHKES: And by the way,</p> <p>3 we've been going a little over an</p> <p>4 hour, if you reach a natural breaking</p> <p>5 point.</p> <p>6 MR. FINCH: Yeah, this is a</p> <p>7 good breaking point.</p> <p>8 MR. CHACHKES: Thank you.</p> <p>9 VIDEOGRAPHER: Okay. The time</p> <p>10 is 2:24 p.m. Off the record.</p> <p>11 (Off the record at 2:24 p.m.)</p> <p>12 VIDEOGRAPHER: Okay. We are</p> <p>13 back on the record. The time is</p> <p>14 2:46 p.m.</p> <p>15 QUESTIONS BY MR. FINCH:</p> <p>16 Q. Good afternoon, Professor Darby</p> <p>17 Dyar. We're back on the record after a short</p> <p>18 break.</p> <p>19 On page 32 of your expert</p> <p>20 witness report, you write that "The SAED</p> <p>21 patterns are labeled with mineral species</p> <p>22 names using only visual inspections based on</p> <p>23 operator experience, methodology for which</p> <p>24 the Longo, Rigler MDL report cite no support.</p> <p>25 This practice may be able to distinguish</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 214</p> <p>1 among species for materials that are already 2 known to contain asbestos, but it may fail in 3 the applications where the spectrum of 4 possible mineralogy is broad." 5 That's what you write, correct? 6 A. That's what I write. 7 Q. What is the basis for your 8 statement that the spectrum of possible 9 mineralogy is broad in the talc mines in 10 Vermont, in Italy, from which Johnson & 11 Johnson obtained its talc? 12 MR. CHACHKES: Objection. 13 THE WITNESS: So because I know 14 nothing about the mineralogy in those 15 localities, all I can say is this 16 general statement, which is that 17 looking at an SAED pattern, which is 18 what Longo and Rigler and their 19 associates admittedly do in their 20 deposition, makes it difficult to 21 distinguish mineral species in 22 applications where the spectrum of 23 possible mineralogy is broad. 24 QUESTIONS BY MR. FINCH: 25 Q. What about in the -- in the</p>	<p style="text-align: right;">Page 216</p> <p>1 different species, correct? 2 MR. CHACHKES: Objection. 3 THE WITNESS: I do use the word 4 "may," and I would say that if you 5 handed me a clump of asbestos and 6 asked me to determine which of the six 7 mineral species it was, I might be 8 able to do -- to use SAED to identify 9 which of the six it was, which is why 10 I deliberately used the word "may" 11 fail. 12 QUESTIONS BY MR. FINCH: 13 Q. Am I correct that you have no 14 basis for your conclusion that the spectrum 15 of possible mineralogy in the Vermont source 16 talc used by Johnson & Johnson -- strike 17 that. 18 Am I correct that you have no 19 basis for your statement in your report that 20 the spectrum of possible mineralogy is broad 21 when it comes to the sources of talc used by 22 Johnson & Johnson? 23 MR. CHACHKES: Objection. 24 THE WITNESS: I stand by my 25 statement because, for example, there</p>
<p style="text-align: right;">Page 215</p> <p>1 spectrum where the possible mineralogy is not 2 broad, as in the case of a Vermont talc mine 3 where a handful of accessory minerals have 4 been identified and that's it? 5 MR. CHACHKES: Objection. 6 MR. LOCKE: Objection. 7 THE WITNESS: Well, I don't 8 know anything about the mineralogy of 9 Vermont talc mines, and so I can't say 10 that there's any independent 11 constraints because I don't know that 12 that is the case. 13 QUESTIONS BY MR. FINCH: 14 Q. Okay. So you do say that "This 15 practice, i.e., analyzing SAED patterns based 16 on operator experience, may be able to 17 distinguish among species for materials that 18 are already known to contain asbestos." 19 So presumably you agree that if 20 the operators already know based on some 21 source that asbestos is among the possible 22 materials in the mix of the sample they're 23 looking for, using SAED to label mineral 24 species with names using visual inspection 25 may be able to distinguish among the</p>	<p style="text-align: right;">Page 217</p> <p>1 are more than a hundred amphibole 2 minerals. It would be very difficult 3 to distinguish them by SAED. 4 And as far as I'm aware, I know 5 nothing about the mineralogy of talc 6 mines from which these particular 7 samples that Drs. Longo and Rigler 8 tested. So to me, the spectrum of 9 possible mineralogy is quite broad. 10 QUESTIONS BY MR. FINCH: 11 Q. Of those hundred amphibole 12 minerals, how many of them have the same 13 chemical signature as anthophyllite or 14 tremolite and an SAED diffraction pattern 15 that is consistent with asbestos and 16 morphology that has structures which have 17 aspect ratios on average greater than 7 to 1 18 and that on PLM are determined to be 19 consistent with asbestos? 20 How many of the hundred 21 amphibole minerals you just talked about meet 22 all those criteria? 23 MR. CHACHKES: Objection. 24 THE WITNESS: Wow, that's 25 another omnibus question, so let's</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 218</p> <p>1 break that down a little bit.</p> <p>2 So chemically, any of the</p> <p>3 amphibole minerals that are either</p> <p>4 magnesium, iron and calcium-bearing or</p> <p>5 just magnesium and iron-bearing would</p> <p>6 all be indistinguishable by EDS.</p> <p>7 If you had one SAED pattern,</p> <p>8 which most of the data in the</p> <p>9 diffraction verification document of</p> <p>10 Dr. Longo's have, they only show one</p> <p>11 particular orientation that is common</p> <p>12 to, as we noted in my document,</p> <p>13 25 percent of all minerals in the</p> <p>14 database from our book.</p> <p>15 So let's see. What else did</p> <p>16 you ask?</p> <p>17 Let's see. And then</p> <p>18 morphology, "has structures which have</p> <p>19 aspect ratios" -- so we haven't even</p> <p>20 really talked about counting criteria,</p> <p>21 which is really what you're -- what</p> <p>22 you're specifying here, 7 to 1. I'm</p> <p>23 not sure where that number is coming</p> <p>24 from.</p> <p>25 And then when you say "on PLM</p>	<p style="text-align: right;">Page 220</p> <p>1 MR. FINCH: Objection. Move to</p> <p>2 strike.</p> <p>3 QUESTIONS BY MR. FINCH:</p> <p>4 Q. My question was: How many,</p> <p>5 sitting here today, can you tell me would</p> <p>6 meet all four of the criteria that I just</p> <p>7 laid out?</p> <p>8 MR. LOCKE: Objection.</p> <p>9 MR. CHACHKES: Objection.</p> <p>10 THE WITNESS: So your criteria</p> <p>11 were simply just names of techniques.</p> <p>12 They weren't specific about the names</p> <p>13 and techniques.</p> <p>14 So if you want to tell me what</p> <p>15 it is about SAED and what it is about</p> <p>16 PLM and what it is about morphology,</p> <p>17 et cetera, et cetera, for each of</p> <p>18 those, then I could probably answer</p> <p>19 your question. I'd be happy to.</p> <p>20 QUESTIONS BY MR. FINCH:</p> <p>21 Q. Do you know as you sit here</p> <p>22 today how many different minerals have been</p> <p>23 identified in Vermont-sourced talc or</p> <p>24 Italian-sourced talc that went into Johnson's</p> <p>25 baby powder?</p>
<p style="text-align: right;">Page 219</p> <p>1 are determined to be consistent with</p> <p>2 asbestos," again, on PLM you can tell</p> <p>3 something about morphology because you</p> <p>4 can measure the dimensions of the</p> <p>5 grain, and if you use an array of</p> <p>6 refracted index oils, you can tell</p> <p>7 something about composition with PLM.</p> <p>8 So those are answers to your</p> <p>9 individual question, and I think it's</p> <p>10 too vague to try to give a straight</p> <p>11 answer to your original question as</p> <p>12 posed.</p> <p>13 QUESTIONS BY MR. FINCH:</p> <p>14 Q. So sitting here today, you</p> <p>15 can't give me a number as to how many of the</p> <p>16 hundred amphiboles that exist would meet all</p> <p>17 those criteria?</p> <p>18 MR. LOCKE: Objection.</p> <p>19 MR. FROST: Objection.</p> <p>20 THE WITNESS: I would say, for</p> <p>21 example, that all of the 100 amphibole</p> <p>22 minerals would meet the SAED one zone</p> <p>23 axis angles -- or values that are in</p> <p>24 the diffraction verification documents</p> <p>25 because they're all amphiboles.</p>	<p style="text-align: right;">Page 221</p> <p>1 A. I have no knowledge of the</p> <p>2 mineralogy of those deposits or, in fact, any</p> <p>3 talc deposits.</p> <p>4 Q. So it could be three minerals,</p> <p>5 it could be five minerals, it could be ten</p> <p>6 minerals; you have no knowledge, correct?</p> <p>7 MR. CHACHKES: Objection.</p> <p>8 MR. LOCKE: Objection.</p> <p>9 THE WITNESS: Correct. I</p> <p>10 believe we've established that I don't</p> <p>11 know anything about the mineralogy of</p> <p>12 Vermont or any other talc deposits,</p> <p>13 aside from the fact that they contain</p> <p>14 talc.</p> <p>15 QUESTIONS BY MR. FINCH:</p> <p>16 Q. Have you ever heard of McCrone</p> <p>17 Laboratories or Walter McCrone Associates?</p> <p>18 A. Yes.</p> <p>19 Q. Do you regard them as a</p> <p>20 well-respected laboratory for the purposes of</p> <p>21 analyzing materials to determine whether or</p> <p>22 not they contain asbestos or other</p> <p>23 contaminants?</p> <p>24 A. I don't know anything about</p> <p>25 that aspect of what they do. I'm only</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 222</p> <p>1 familiar with the fact that they teach</p> <p>2 classes in optical microscopy.</p> <p>3 Q. And they teach classes in how</p> <p>4 to use a microscope to identify materials,</p> <p>5 correct?</p> <p>6 A. They teach classes in how to do</p> <p>7 fundamental measurements on a microscope,</p> <p>8 yes.</p> <p>9 Q. Have you ever attended a class</p> <p>10 taught by Walter McCrone and Associates or</p> <p>11 McCrone?</p> <p>12 A. I teach my own classes on</p> <p>13 optical microscopy, so, no, I have no need</p> <p>14 and, therefore, have never attended a class</p> <p>15 taught by McCrone or anyone having to do with</p> <p>16 McCrone.</p> <p>17 Q. Have you ever heard any</p> <p>18 significant criticisms of their laboratories</p> <p>19 in your field?</p> <p>20 A. McCrone is not an academic</p> <p>21 laboratory. It's not something that research</p> <p>22 scientists do. Optical microscopy is</p> <p>23 generally in the toolkit of mineralogy</p> <p>24 researchers, and so there would no need to</p> <p>25 use any laboratory. And, therefore, I barely</p>	<p style="text-align: right;">Page 224</p> <p>1 Q. And 18 is?</p> <p>2 A. November 5th.</p> <p>3 Q. All right. I want to do them</p> <p>4 20 -- I'm going to do them in reverse</p> <p>5 chronological order, going backward in time,</p> <p>6 so starting with Exhibit 20.</p> <p>7 Do you have that?</p> <p>8 A. I do.</p> <p>9 Q. This is a May 24, 1976 letter</p> <p>10 to Walter McCrone Associates from Roger</p> <p>11 Miller, who was the president of Windsor</p> <p>12 Minerals.</p> <p>13 Do you see that?</p> <p>14 A. That's what it looks like, yes.</p> <p>15 Q. Do you have any understanding</p> <p>16 of who Roger Miller is or what Windsor</p> <p>17 Minerals is?</p> <p>18 A. Never heard of him.</p> <p>19 Q. All right. If I were to</p> <p>20 represent to you that Windsor Minerals was a</p> <p>21 Johnson & Johnson subsidiary that owned the</p> <p>22 mines from which it mined talc for cosmetic</p> <p>23 talc, do you have anything to dispute that</p> <p>24 statement?</p> <p>25 MR. CHACHKES: Objection.</p>
<p style="text-align: right;">Page 223</p> <p>1 know of McCrone.</p> <p>2 Q. Oh, so you haven't -- as you</p> <p>3 sit here today, there's not any criticisms</p> <p>4 you have or you can think of of McCrone</p> <p>5 Associates?</p> <p>6 A. I don't have enough information</p> <p>7 to have an opinion.</p> <p>8 (Dyar Exhibits 18, 19 and 20</p> <p>9 marked for identification.)</p> <p>10 QUESTIONS BY MR. FINCH:</p> <p>11 Q. All right. I've marked what's</p> <p>12 been Exhibits 20 --</p> <p>13 MR. CHACHKES: 18.</p> <p>14 QUESTIONS BY MR. FINCH:</p> <p>15 Q. -- 18 and 19.</p> <p>16 MR. CHACHKES: Yeah.</p> <p>17 QUESTIONS BY MR. FINCH:</p> <p>18 Q. Yeah. 20 is a May 24, 1976</p> <p>19 document; is that right?</p> <p>20 A. Oh, wait. 20 you want to go to</p> <p>21 first?</p> <p>22 Q. Yes.</p> <p>23 A. Yes, it says May 24th.</p> <p>24 Q. Okay. And 19, which one is 19?</p> <p>25 A. 19 is July 1, 1975.</p>	<p style="text-align: right;">Page 225</p> <p>1 THE WITNESS: I can neither</p> <p>2 affirm nor dispute that statement.</p> <p>3 QUESTIONS BY MR. FINCH:</p> <p>4 Q. All right. Exhibit 20 states</p> <p>5 that "The samples which are relevant to the</p> <p>6 production and sale of cosmetic talc in the</p> <p>7 US and Canadian markets are those bearing the</p> <p>8 letters HC as part of their prefix. The</p> <p>9 dates included in the identifier are the</p> <p>10 dates on which the material was processed."</p> <p>11 Do you see that?</p> <p>12 A. You read that correctly, yes.</p> <p>13 Q. Okay. So this is the president</p> <p>14 of Windsor Minerals writing to the people at</p> <p>15 McCrone Associates what the terminology in</p> <p>16 the letter means, what HC means, correct?</p> <p>17 A. That's what it appears. The</p> <p>18 letter's not signed.</p> <p>19 Q. Back in the 1970s, wasn't it a</p> <p>20 common practice when people wrote letters</p> <p>21 that there be a carbon copy and sometimes</p> <p>22 the -- there wasn't -- the Xerox machine was</p> <p>23 not as ubiquitous as it is now, and you</p> <p>24 wouldn't always have the signed copy in the</p> <p>25 file?</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 226</p> <p>1 MR. CHACHKES: Objection.</p> <p>2 THE WITNESS: It's perfectly</p> <p>3 easy to sign a carbon copy.</p> <p>4 QUESTIONS BY MR. FINCH:</p> <p>5 Q. Be that as it may, Windsor</p> <p>6 Minerals -- you see this is -- this is a</p> <p>7 document produced from the files of Johnson &</p> <p>8 Johnson at the bottom?</p> <p>9 MR. FROST: Objection.</p> <p>10 QUESTIONS BY MR. FINCH:</p> <p>11 Q. J&J talc?</p> <p>12 A. I have -- I have no knowledge</p> <p>13 of that, other than your assertion and this</p> <p>14 cryptic notation which looks like it was</p> <p>15 added after the fact.</p> <p>16 Q. Turning now to Exhibit 18, and</p> <p>17 keep Exhibit 20 handy.</p> <p>18 "This letter will supplement</p> <p>19 our report of 1 July 1975 on a series of talc</p> <p>20 ore samples which we have analyzed for you.</p> <p>21 Table 1 shows the actual fiber counts and the</p> <p>22 approximate equivalent concentration in parts</p> <p>23 per million of amphibole particles which we</p> <p>24 found in these samples. Some of them seem</p> <p>25 rather high. Most of these come in bundles</p>	<p style="text-align: right;">Page 228</p> <p>1 these two documents.</p> <p>2 For example, after this</p> <p>3 testing, were these samples actually</p> <p>4 used? I can't tell.</p> <p>5 It says "amphibole." Which</p> <p>6 amphibole? Is it one of the regulated</p> <p>7 amphibole minerals?</p> <p>8 QUESTIONS BY MR. FINCH:</p> <p>9 Q. It says "fibers of asbestos,"</p> <p>10 correct?</p> <p>11 A. It does say "fibers of</p> <p>12 asbestos." I would ask, how are they</p> <p>13 defining that?</p> <p>14 This was 1975, and there's no</p> <p>15 explicit explanation here, so I would wonder</p> <p>16 how they defined that.</p> <p>17 So there's many murky things</p> <p>18 about this document that make me feel like</p> <p>19 it's being taken out of context.</p> <p>20 Q. And if you were going to</p> <p>21 analyze this document as a scientist, isn't</p> <p>22 it correct that you would want to see the</p> <p>23 photomicrographs that McCrone and Associates</p> <p>24 took and their analyses, both chemical</p> <p>25 analyses and any other analyses, they</p>
<p style="text-align: right;">Page 227</p> <p>1 of one, two or three fibers, anything from</p> <p>2 two to five amphiboles in a bundle."</p> <p>3 And it's reporting on the</p> <p>4 results from McCrone to the Windsor Mineral</p> <p>5 Company, correct?</p> <p>6 A. Apparently.</p> <p>7 Q. All right. And on Table 1 on</p> <p>8 the second page of the document, the back</p> <p>9 page, there is a column labeled "Fibers of</p> <p>10 Asbestos"?</p> <p>11 A. That's what it says.</p> <p>12 Q. And then it -- by</p> <p>13 cross-referencing the tabs, you can take the</p> <p>14 sample numbers and if it's -- see whether</p> <p>15 it's HC or GI or WI?</p> <p>16 A. Yes, I see that.</p> <p>17 Q. All right. Does this document</p> <p>18 suggest to you that McCrone and Associates</p> <p>19 identified fibers of asbestos in samples of</p> <p>20 ore from a Vermont mine owned by the Windsor</p> <p>21 Mineral Company which were used in the</p> <p>22 production of cosmetic talc, HC?</p> <p>23 MR. FROST: Objection.</p> <p>24 THE WITNESS: I have no</p> <p>25 knowledge of the connection between</p>	<p style="text-align: right;">Page 229</p> <p>1 provided on the documents?</p> <p>2 MR. CHACHKES: Objection.</p> <p>3 THE WITNESS: Well, I would ask</p> <p>4 why, as a scientist, I would want to</p> <p>5 analyze something like this. I would</p> <p>6 much prefer to analyze a formal</p> <p>7 report.</p> <p>8 QUESTIONS BY MR. FINCH:</p> <p>9 Q. If there were a formal report</p> <p>10 that once upon a time went along with this</p> <p>11 and contained photomicrographs -- you okay,</p> <p>12 ma'am? -- or count -- or count sheets or</p> <p>13 diffraction patterns, would that be</p> <p>14 information that you would want to consider</p> <p>15 to analyze whether or not this letter report</p> <p>16 from McCrone is accurate and reliable?</p> <p>17 MR. CHACHKES: Objection.</p> <p>18 THE WITNESS: I don't know.</p> <p>19 We're going far outside the scope of</p> <p>20 my remit here, which is to evaluate</p> <p>21 methodology. But I would say, again,</p> <p>22 there's no context here. There's</p> <p>23 no -- I have no way of knowing whether</p> <p>24 the samples in this report are ones</p> <p>25 that were ever even involved in a mine</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 230</p> <p>1 or even used in commercial production. 2 There's not enough information here to 3 make a judgment. 4 And if they weren't used, then 5 there wouldn't be any -- need to be 6 any more information. 7 QUESTIONS BY MR. FINCH: 8 Q. But in order to understand the 9 context, you agree with me that it would be 10 useful to have the backup data that underlies 11 this report? 12 MR. CHACHKES: Objection. 13 THE WITNESS: I'm still not 14 understanding why I would want to be 15 examining this report. I'm supposed 16 to be evaluating methodology here, and 17 you're asking me to evaluate a random 18 report with no context about which I 19 know nothing. 20 There's nothing in here to 21 indicate that the samples they're 22 talking about were ever -- ever even 23 had anything to do with talc that was 24 actually produced from Vermont mines 25 or anywhere else.</p>	<p style="text-align: right;">Page 232</p> <p>1 misrepresenting the documents. 2 So with that note... 3 THE WITNESS: I choose not to 4 answer. 5 QUESTIONS BY MR. FINCH: 6 Q. You have not, as part of your 7 work in this case, asked Johnson & Johnson 8 for all of the testing results that have ever 9 been done on either the talc ore or the baby 10 powder product itself, correct? 11 A. So my role here was to evaluate 12 methodology used by Longo and Rigler. It was 13 not to evaluate testing protocols used by 14 Johnson & Johnson. 15 I have no opinion of -- no 16 knowledge of those and no opinion on those. 17 Q. Are you familiar with the 18 testing protocol J41 -- J4-1? 19 A. I don't believe so. 20 Q. It's the testing protocol that 21 the talc manufacturers voluntarily put into 22 place in the mid-'70s for the analysis of 23 asbestos in talc. 24 Are you familiar with that? 25 MR. LOCKE: Objection.</p>
<p style="text-align: right;">Page 231</p> <p>1 QUESTIONS BY MR. FINCH: 2 Q. I want you to assume that these 3 documents are contemporaneous reports of 4 McCrone analyses of talc from the very mines 5 that Johnson & Johnson used to source its 6 baby powder in the 1970s, and that in 7 Exhibits 18 and 19 McCrone states that they 8 found fibers of asbestos, in the case of 9 Exhibit 18, and Exhibit 19, confirmed 10 asbestos visual on page 2, in multiple 11 samples of talc ore from the Vermont mines 12 that were used to source cosmetic talcum 13 products. 14 A. So -- 15 MR. CHACHKES: So -- go ahead. 16 QUESTIONS BY MR. FINCH: 17 Q. So based on that set of 18 assumptions, Doctor, do you have any basis to 19 say that this is not evidence that one of the 20 minerals that can potentially be found in 21 talc from Vermont is amphibole asbestos? 22 MR. CHACHKES: So objection. 23 You don't have to take those 24 assumptions. 25 You shouldn't be</p>	<p style="text-align: right;">Page 233</p> <p>1 MR. CHACHKES: Objection. 2 THE WITNESS: No. 3 QUESTIONS BY MR. FINCH: 4 Q. If I were to tell you that it 5 is a combination of XRD and optical 6 microscopy, is the J4 method, would you agree 7 with me that those two methodologies would 8 not be able to detect asbestos fibers in talc 9 at a concentration below 0.1 percent? 10 MR. CHACHKES: Objection. 11 MR. LOCKE: Objection. 12 THE WITNESS: Oh, I would need 13 a lot more information than your 14 random statement that it meets XRD and 15 optical microscopy. I'd need to 16 examine that document to be able to 17 render an opinion. 18 QUESTIONS BY MR. FINCH: 19 Q. You're not -- I think you just 20 said two questions ago you're not giving any 21 opinions that Johnson & Johnson's historical 22 methodologies for testing its talc for the 23 presence of asbestos are accurate or 24 reliable; is that correct? 25 MR. CHACHKES: Objection.</p>

Melinda Darby Dyar, Ph.D.

Page 234	Page 236
<p>1 THE WITNESS: I'm not giving 2 any opinion, period, on testing 3 procedures from Johnson & Johnson 4 because I have no knowledge of them 5 and, therefore, cannot comment in any 6 way. 7 QUESTIONS BY MR. FINCH: 8 Q. All right. On page 33 of your 9 report, you reference a term "unspecified 10 constant." 11 Do you see that? 12 A. Yes. 13 MR. CHACHKES: I'm sorry, on 14 page 33? 15 MR. FINCH: Page 33 of her 16 report. 17 THE WITNESS: Yep, it's right 18 here. 19 MR. CHACHKES: Okay. Thanks. 20 QUESTIONS BY MR. FINCH: 21 Q. How do you calculate the camera 22 constant for doing SAED? 23 A. So the camera constant is 24 calibrated for each individual apparatus 25 using a reference standard, and it allows you</p>	<p>1 images. 2 Q. Isn't it true -- 3 MR. FINCH: Mark this as the 4 next exhibit. It's Exhibit 21. 5 (Dyar Exhibit 21 marked for 6 identification.) 7 QUESTIONS BY MR. FINCH: 8 Q. In the diffraction verification 9 documents -- 10 A. Uh-huh. 11 Q. -- in every one there is a 12 field called camera K, camera K, camera K? 13 A. And in every one it's given in 14 units of pixel per angstrom, which is a 15 useless unit. 16 So I stand by my statement that 17 the constant is unspecified in terms that are 18 useful enough to allow someone else to 19 interpret the images, which was the point of 20 my statement there. 21 Q. Okay. So you're saying that -- 22 did you understand camera K to be a reference 23 to camera constant or not? 24 A. I did not know. There was not 25 enough information. That is not defined</p>
Page 235	Page 237
<p>1 to relate the spacial distances in an image 2 to actual physical distances. And it varies 3 by instrument, and it is explicitly not 4 provided. Even though the definition of 5 camera constant is given on each page in the 6 diffraction verification document, the actual 7 value for their instrument or instruments is 8 not given. 9 Q. Could you turn to page 37? 10 A. (Witness complies.) 11 Q. What does camera K refer to? 12 A. I have no idea. 13 Q. You don't think that refers to 14 camera constant? 15 A. I was not going to guess. 16 Q. If that, in fact, does -- are 17 you familiar with the scientific -- 18 A. I am, but in point of fact, 19 it's expressed, you'll notice, in units of 20 pixel per angstrom. And the images in these 21 documents, which are many times scanned, no 22 longer have any pixels. 23 So even if that is the camera 24 constant, this number is completely useless 25 because there are no pixels in any of these</p>	<p>1 anywhere in any of the documents I saw. 2 And even if it had been, I have 3 no way of using that information because 4 there's no pixels in any of the images. 5 Q. The pixels in the images are 6 the SAED images that you've shown some 7 examples of, for example, on page 28 of your 8 report; is that right? 9 A. Certainly. 10 Q. And your -- my understanding is 11 it's your complaint that because the images 12 are not sufficiently clear, you can't verify 13 the camera constant in the diffraction 14 verification worksheets? 15 A. Yes. Using something that's 16 expressed in pixels per angstrom implies that 17 in order to use it, you would need to be able 18 to count pixels, and that is impossible in 19 these images. 20 Q. Was it impossible for the 21 operator at the time he or she was analyzing 22 the particle in realtime using the 23 microscope? 24 A. Presumably the personnel at the 25 Longo, Rigler company are familiar with the</p>

60 (Pages 234 to 237)

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 238</p> <p>1 camera constants for their apparatus, yes. 2 And in fact, they used said 3 camera constants to determine these values 4 that are at the bottom of each of these 5 pages. But I cannot go backwards. 6 Q. So you can't reverse-engineer 7 it, in other words, and that's your 8 criticism? 9 A. Correct. These documents do 10 not provide a camera constant in any useful 11 units, thereby making it impossible to 12 corroborate their measurements. 13 Q. Okay. But in fact they did 14 have a camera constant. You just -- your 15 criticism is that the pixels are not 16 sufficiently clear for you to recalculate 17 their camera constant for each of the 18 diffraction patterns that they were providing 19 data for; is that correct? 20 MR. CHACHKES: Objection. 21 MR. LOCKE: Objection. 22 THE WITNESS: The point of my 23 statement on page 33 is "lacking 24 knowledge of that constant, D spacings 25 cannot be easily verified for the</p>	<p style="text-align: right;">Page 240</p> <p>1 Rigler failed to demonstrate that 2 their D spacings are reproducible or 3 verifiable independently. 4 QUESTIONS BY MR. FINCH: 5 Q. Do you agree that the 6 anthophyllite solid solution series includes 7 cummingtonite? 8 A. So I don't believe that that 9 vocabulary is consistent with the current 10 terminology for amphiboles. 11 If you look on page 607 of my 12 book, you can see that there are about seven 13 minerals which are in the same subgroup of 14 amphibole minerals. And one could say that 15 there might potentially be solid solution 16 amongst all seven of those primary minerals, 17 each of which has from four to seven related 18 species and many subspecies. 19 So it's a little restrictive to 20 say that those belong to a single solid 21 solution series. It's not really the 22 appropriate term to use for the variation of 23 chemistry in amphibole minerals. 24 Q. On page 35 you state, last 25 paragraph, "A more comprehensive analysis</p>
<p style="text-align: right;">Page 239</p> <p>1 patterns in their reports." 2 And the most important part of 3 that sentence is that there is not 4 enough information here or in any of 5 these diffraction verification 6 documents for me to confirm the D 7 spacing values that they list. 8 QUESTIONS BY MR. FINCH: 9 Q. But you would agree with me 10 that on the face of each of the documents 11 there is a notation that has camera K, which 12 a scientist could conclude or should conclude 13 means camera constant for that particular 14 data set, correct? 15 MR. LOCKE: Objection. 16 MR. CHACHKES: Objection. 17 THE WITNESS: That's completely 18 conjectural. I have no reason to 19 expect that. K is not the first 20 letter of the word "constant." 21 So lacking any information to 22 tell me that that's what it was, and 23 lacking any way to use that value 24 because of the way it's expressed in 25 units, I feel that Drs. Longo and</p>	<p style="text-align: right;">Page 241</p> <p>1 using the American mineralogists crystal 2 structure database shows that more than 1,000 3 crystal structures have at least one D 4 spacing in the range above." 5 How many of those 1,000 crystal 6 structures have been found in the Vermont 7 talc mines or the Italian talc mines used by 8 Johnson & Johnson? 9 A. I have no idea, because I know 10 nothing about the mineralogy of talc mines in 11 Vermont or anywhere else. 12 Q. On page 37, section F, you 13 identify indefensible or unfeasible D 14 spacings in the Longo and Rigler diffraction 15 verification documents. 16 It looks to me like you 17 identify two samples where either the 18 measurement itself is bad or they cannot be 19 anthophyllite or both; is that correct? 20 A. That's correct. 21 Q. Out of how many different 22 samples? 23 A. I'd have to look at the 24 diffraction verification documents. I don't 25 recall exactly how many samples they did. I</p>

Melinda Darby Dyar, Ph.D.

Page 242	Page 244
<p>1 know it was six samples.</p> <p>2 Q. But it was how many different</p> <p>3 particles identified?</p> <p>4 A. I honestly don't recall. We</p> <p>5 can certainly look it up.</p> <p>6 Q. Would you agree that it's over</p> <p>7 180?</p> <p>8 A. I honestly don't recall, but</p> <p>9 I'd be happy to look it up if you --</p> <p>10 Q. Okay. Go ahead and look it up.</p> <p>11 A. Well, let's get out those</p> <p>12 diffraction verification documents.</p> <p>13 MR. CHACHKES: I'm not</p> <p>14 trying --</p> <p>15 THE WITNESS: Are they not --</p> <p>16 MR. FROST: They're 5,000</p> <p>17 pages.</p> <p>18 THE WITNESS: No, no, he's just</p> <p>19 talking about the diffraction</p> <p>20 verification documents. These are the</p> <p>21 only places where there are any HKL</p> <p>22 measurements.</p> <p>23 QUESTIONS BY MR. FINCH:</p> <p>24 Q. Do you have your materials that</p> <p>25 you reviewed of Dr. Longo's with you?</p>	<p>1 on at least two zone axes is relying on</p> <p>2 Yamate 3 methodology, correct?</p> <p>3 MR. CHACHKES: Objection.</p> <p>4 THE WITNESS: It's supported by</p> <p>5 the Yamate 3 -- or the Yamate</p> <p>6 recommendation, but it's common sense</p> <p>7 to anyone who knows anything about</p> <p>8 crystallography.</p> <p>9 And I can explain it as saying</p> <p>10 that minerals are three-dimensional</p> <p>11 structures, and so if you only look at</p> <p>12 it from one angle, you would know</p> <p>13 nothing about the third dimension and,</p> <p>14 therefore, your identification is</p> <p>15 nonunique.</p> <p>16 QUESTIONS BY MR. FINCH:</p> <p>17 Q. But if the analyst is tilting</p> <p>18 the goniometer to look at the structure while</p> <p>19 he's examining it under the electron</p> <p>20 microscope, isn't it true that he is making a</p> <p>21 determination in realtime as to whether or</p> <p>22 not the crystalline structure is or is not</p> <p>23 consistent with asbestos?</p> <p>24 A. According to Dr. Longo's and</p> <p>25 Rigler's depositions, that's what they're</p>
Page 243	Page 245
<p>1 MR. CHACHKES: We may. At some</p> <p>2 point maybe after the break I could</p> <p>3 check.</p> <p>4 MR. FINCH: All right. We'll</p> <p>5 check that after the break.</p> <p>6 THE WITNESS: There are</p> <p>7 certainly less than 200.</p> <p>8 QUESTIONS BY MR. FINCH:</p> <p>9 Q. Okay. But 180, we can -- I</p> <p>10 mean, it's a number we could look up, but --</p> <p>11 A. I know for a fact it's only six</p> <p>12 different samples. In one case there are</p> <p>13 four different crystals -- or particles, and</p> <p>14 I don't recall for the other five samples how</p> <p>15 many particles they looked at.</p> <p>16 In some senses it doesn't</p> <p>17 matter how many particles they looked at,</p> <p>18 because there is in -- no evidence in any of</p> <p>19 those diffraction verification documents that</p> <p>20 they looked at two different zone axes. So</p> <p>21 my conclusions here about the vast number of</p> <p>22 samples that they can represent stand.</p> <p>23 Q. And your opinion that in order</p> <p>24 to test a material for asbestos using EPA</p> <p>25 methodology you have to have a confirmation</p>	<p>1 doing. They're looking at the screen and</p> <p>2 making a decision. They're not actually</p> <p>3 using zone axes. That is what his deposition</p> <p>4 states.</p> <p>5 I give that -- citations to</p> <p>6 that as footnotes in here, 53, 54 and 55.</p> <p>7 Q. Okay. Let's go to page 24 of</p> <p>8 the report.</p> <p>9 A. Uh-huh.</p> <p>10 Q. All right. You have on page --</p> <p>11 pages 24 through 26 an analysis of the six</p> <p>12 different analysts in -- working with or for</p> <p>13 Dr. Longo as to the percentages -- on</p> <p>14 page 25, the percentages that identify</p> <p>15 tremolite versus anthophyllite.</p> <p>16 On page 26, you've got a graph</p> <p>17 of mineral species identification from</p> <p>18 Vermont, and then at the bottom of page 26</p> <p>19 you have a time chart that shows tremolite</p> <p>20 versus anthophyllite over time.</p> <p>21 That's Figures 8, 9 and 10 in</p> <p>22 your report.</p> <p>23 A. Yes, and these data were simply</p> <p>24 taken from the information in Dr. Longo's</p> <p>25 reports.</p>

Melinda Darby Dyar, Ph.D.

Page 246	Page 248
<p>1 Q. Okay.</p> <p>2 A. As seen in the spreadsheets</p> <p>3 with which we have provided you.</p> <p>4 Q. Right, the backup data that you</p> <p>5 gave us last night.</p> <p>6 Let me ask you this --</p> <p>7 MR. CHACHKES: Just to be</p> <p>8 clear, that's Longo's data. You know</p> <p>9 that, right?</p> <p>10 MR. FINCH: I understand that.</p> <p>11 MR. CHACHKES: Okay.</p> <p>12 MR. FINCH: It's her analysis</p> <p>13 of Longo's data.</p> <p>14 MR. CHACHKES: No, it's Longo's</p> <p>15 data.</p> <p>16 THE WITNESS: Yes. There's no</p> <p>17 analysis involved here. This is just</p> <p>18 a graphical representation of the data</p> <p>19 that are given by Dr. Longo.</p> <p>20 MR. FINCH: Okay. All right.</p> <p>21 THE WITNESS: That does not</p> <p>22 involve analysis.</p> <p>23 QUESTIONS BY MR. FINCH:</p> <p>24 Q. You say that "data in the</p> <p>25 Longo, Rigler MAS reports indicates that</p>	<p>1 samples in these reports were assigned at</p> <p>2 random, and therefore, given his assertion,</p> <p>3 it seems highly unlikely that this</p> <p>4 distribution over time would be seen.</p> <p>5 Q. Well, if the material that he</p> <p>6 had to test through the end of 2017 consisted</p> <p>7 of three bottles of Vermont-sourced talc and</p> <p>8 the rest from other parts of the world,</p> <p>9 either Italy or China, and the analysis done</p> <p>10 in 2018 where the samples -- the majority of</p> <p>11 which came from Vermont-sourced talc,</p> <p>12 wouldn't you expect to see -- or isn't it</p> <p>13 possible you could have a difference in the</p> <p>14 percentage of tremolite versus the percentage</p> <p>15 of anthophyllite just based on the source</p> <p>16 mine from which the material came?</p> <p>17 MR. LOCKE: Objection.</p> <p>18 MR. CHACHKES: Objection.</p> <p>19 THE WITNESS: If, in fact,</p> <p>20 Dr. Longo had stated something to that</p> <p>21 effect in his deposition, that might</p> <p>22 be a possible conclusion.</p> <p>23 But the fact is that Dr. Longo</p> <p>24 says that these samples were assigned</p> <p>25 at random and, therefore, I have no</p>
Page 247	Page 249
<p>1 samples mined from Vermont appear to have</p> <p>2 75 percent anthophyllite and 25 percent</p> <p>3 tremolite."</p> <p>4 What's the basis of that</p> <p>5 statement?</p> <p>6 A. The data that are in the</p> <p>7 spreadsheet that you were provided with.</p> <p>8 Calculations are shown there.</p> <p>9 Q. In Figure 10, there are reports</p> <p>10 done in 2017 -- first of all, what are the --</p> <p>11 what are the dates on the bottom row of</p> <p>12 Figure 10?</p> <p>13 A. So those are months.</p> <p>14 Q. Yes.</p> <p>15 A. And they refer to the stated</p> <p>16 date of analyses that are given on the third</p> <p>17 page of the TEM reports in all of Dr. Longo's</p> <p>18 reports.</p> <p>19 Q. Would you agree with me that</p> <p>20 the percentage of tremolite versus the</p> <p>21 percentage of anthophyllite found in the</p> <p>22 samples analyzed could depend on the source</p> <p>23 mine from which it came?</p> <p>24 A. Possibly, yes. But in</p> <p>25 deposition, Dr. Longo stated that all of the</p>	<p>1 reason to expect or suspect that any</p> <p>2 particular mine was sourced and</p> <p>3 provided the analyses at random in</p> <p>4 this particular time frame.</p> <p>5 QUESTIONS BY MR. FINCH:</p> <p>6 Q. Isn't it true that in MDL</p> <p>7 reports he lists out the -- do you know when</p> <p>8 Dr. Longo received the MDL samples?</p> <p>9 A. I'm sure that's buried in the</p> <p>10 chain of custody documents, but I didn't pay</p> <p>11 much attention to those because when he</p> <p>12 received them was not relevant to my mandate</p> <p>13 of assessing the methodology used.</p> <p>14 Q. If five analysts are provided</p> <p>15 with a total of 32 samples, 29 from an</p> <p>16 Italian mine, 3 from a Vermont mine, and</p> <p>17 they're randomly distributed in 2017, isn't</p> <p>18 it the case that you could have a</p> <p>19 distribution pattern very similar to</p> <p>20 Figure 10 if those analysts were provided</p> <p>21 with many, many more samples from Vermont in</p> <p>22 2018, and it was randomly distributed along</p> <p>23 the five -- the same five people? That is</p> <p>24 one explanation for this time dichotomy you</p> <p>25 show in Figure 10, correct?</p>

63 (Pages 246 to 249)

Melinda Darby Dyar, Ph.D.

Page 250	Page 252
<p>1 MR. FROST: Objection.</p> <p>2 THE WITNESS: Boy, that's a lot</p> <p>3 of hypotheticals there.</p> <p>4 I'd have to sit down and look</p> <p>5 at the math and review my data, which</p> <p>6 are not -- which were provided to you</p> <p>7 but not included in this report, that</p> <p>8 suggests that there's a 75 percent to</p> <p>9 25 percent of anthophyllite to</p> <p>10 tremolite.</p> <p>11 So, for example, in your case,</p> <p>12 you're saying that in 2017 perhaps</p> <p>13 those samples were all from Vermont.</p> <p>14 Yet if they were from Vermont, then we</p> <p>15 should have seen a lot more</p> <p>16 anthophyllite, 75 percent more to be</p> <p>17 precise.</p> <p>18 So I'm not sure where you're</p> <p>19 going with that question.</p> <p>20 QUESTIONS BY MR. FINCH:</p> <p>21 Q. No, you've got it backwards.</p> <p>22 If virtually all the samples in</p> <p>23 2017 up through March of 2018 came --</p> <p>24 A. Are tremolite.</p> <p>25 Q. -- from sources other than</p>	<p>1 that you're bending your assertions to</p> <p>2 match the graph. And I'd rather know</p> <p>3 the facts on what the distributions of</p> <p>4 species are in these other deposits,</p> <p>5 which I don't, in order to support or</p> <p>6 negate your hypothesis.</p> <p>7 QUESTIONS BY MR. FINCH:</p> <p>8 Q. Okay. Isn't it true that you</p> <p>9 don't know the distribution of tremolite</p> <p>10 versus anthophyllite in the samples from</p> <p>11 outside of Vermont that Dr. Longo's</p> <p>12 laboratory tested? Correct?</p> <p>13 MR. CHACHKES: Objection.</p> <p>14 THE WITNESS: That is correct.</p> <p>15 All I know is that Dr. Longo stated</p> <p>16 that the selection and assignment of</p> <p>17 samples in this study was random.</p> <p>18 And, therefore, I have no reason to</p> <p>19 believe your conjecture that there was</p> <p>20 a bias in geographical assignment of</p> <p>21 these samples over time, because</p> <p>22 Dr. Longo himself said that there was</p> <p>23 not. He said that they were assigned</p> <p>24 at random.</p> <p>25</p>
Page 251	Page 253
<p>1 Vermont --</p> <p>2 A. Ah.</p> <p>3 Q. -- you would expect to see a</p> <p>4 lot more tremolite than anthophyllite,</p> <p>5 correct?</p> <p>6 MR. LOCKE: Objection.</p> <p>7 THE WITNESS: That's not true,</p> <p>8 because I actually don't know what the</p> <p>9 percentage of anthophyllite to</p> <p>10 tremolite is in the other mines. I</p> <p>11 only have -- happen to know it for</p> <p>12 Vermont.</p> <p>13 QUESTIONS BY MR. FINCH:</p> <p>14 Q. If, in fact, it's 100 percent</p> <p>15 tremolite and zero percent anthophyllite in</p> <p>16 the other mines, wouldn't the graphic</p> <p>17 Figure 10 look exactly the same?</p> <p>18 You'd see a lot more tremolite</p> <p>19 in the samples that Dr. Longo was able to</p> <p>20 test prior to March of 2017 where the mines</p> <p>21 were predominantly Italy, sources</p> <p>22 predominantly Italy, versus the MDL samples</p> <p>23 where the source was predominantly Vermont?</p> <p>24 MR. FROST: Objection.</p> <p>25 THE WITNESS: It seems to me</p>	<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. He said they were assigned at</p> <p>3 random. He was not asked what percentage of</p> <p>4 the -- isn't it fair to conclude that it was</p> <p>5 random for the samples that he had at the</p> <p>6 time they were being tested, and he didn't go</p> <p>7 back and randomly assign all the samples to</p> <p>8 his analysts after he got all the MDL</p> <p>9 samples?</p> <p>10 MR. CHACHKES: Objection.</p> <p>11 THE WITNESS: You know, there's</p> <p>12 not enough information to be able to</p> <p>13 answer that question.</p> <p>14 I did not compile the</p> <p>15 information on when specific samples</p> <p>16 were obtained, so I can't either</p> <p>17 support or negate your assertion</p> <p>18 without reconsidering the data in the</p> <p>19 report.</p> <p>20 QUESTIONS BY MR. FINCH:</p> <p>21 Q. All right. Would you agree</p> <p>22 with me that Mehrdad Motamedi and Anthony</p> <p>23 Keaton had very consistent findings of</p> <p>24 tremolite versus anthophyllite for the 179</p> <p>25 particles that Motamedi examined and Keaton's</p>

64 (Pages 250 to 253)

Melinda Darby Dyar, Ph.D.

Page 254	Page 256
<p>1 289 particles?</p> <p>2 A. Actually, no, I would say it's</p> <p>3 kind of odd that Keaton identified a fair</p> <p>4 number of ferro-anthophyllites and Motamedi</p> <p>5 did not.</p> <p>6 Q. Do you know the source of the</p> <p>7 talc for each of the six analysts -- each of</p> <p>8 the five analysts identified in Figure 8?</p> <p>9 How many -- how many Vermont-sourced talc did</p> <p>10 Jayme Callan analyze versus other places; how</p> <p>11 many Motamedi did; how many Keaton did?</p> <p>12 A. Well, that information is in</p> <p>13 Figure 8.</p> <p>14 Q. How is it in Figure 8? It just</p> <p>15 says what the --</p> <p>16 A. It says where it came from,</p> <p>17 either Vermont or other.</p> <p>18 Q. That's in Figure 9.</p> <p>19 A. I'm sorry, Figure 9.</p> <p>20 Q. What about 8?</p> <p>21 A. No, I didn't happen to figure</p> <p>22 out a way to color code Figure 8 to indicate</p> <p>23 where the samples came from. I could have</p> <p>24 done that, I suppose, but it didn't even</p> <p>25 occur to me to do that.</p>	<p>1 with that 75/25 value for Vermont.</p> <p>2 MR. FINCH: This is probably a</p> <p>3 good place to take another break.</p> <p>4 MR. CHACHKES: Okay.</p> <p>5 VIDEOGRAPHER: The time is</p> <p>6 3:35 p.m. Off the record.</p> <p>7 (Off the record at 3:35 p.m.)</p> <p>8 VIDEOGRAPHER: Okay. All</p> <p>9 right. We are now back on the record.</p> <p>10 The time is 3:54 p.m.</p> <p>11 QUESTIONS BY MR. FINCH:</p> <p>12 Q. We're back on the record after</p> <p>13 a short break.</p> <p>14 Ms. Darby Dyar, do you have</p> <p>15 Exhibit 19 in your pile still?</p> <p>16 A. Yes. Somewhere. Yes.</p> <p>17 Q. Do you consider yourself to be</p> <p>18 an expert in using electron microscopy and</p> <p>19 selected area diffraction to determine the</p> <p>20 extent of amphiboles or serpentine</p> <p>21 contamination in samples of talc?</p> <p>22 A. So, first of all, no one would</p> <p>23 use SAED to determine the extent of</p> <p>24 amphiboles or serpentine contamination</p> <p>25 because you can only do one at a time. So</p>
Page 255	Page 257
<p>1 I'm looking at methodology and</p> <p>2 I'm trying to assess whether the analysts who</p> <p>3 did this work were consistent and, therefore,</p> <p>4 I made graphical representations of the data</p> <p>5 in their own reports, but, no, I did not make</p> <p>6 yet another graphical representation that</p> <p>7 would have included both the minerals</p> <p>8 identified and the locations from which they</p> <p>9 came.</p> <p>10 Q. Would you agree with me that</p> <p>11 the breakdown as between tremolite and</p> <p>12 anthophyllite could vary among analysts if</p> <p>13 one of the analysts was reviewing more</p> <p>14 Italian-sourced talc and the other analyst</p> <p>15 was reviewing more Vermont-sourced talc?</p> <p>16 A. I don't have enough information</p> <p>17 to know anything about the ratio of those in</p> <p>18 the other mines. So I can't address that</p> <p>19 question.</p> <p>20 In point of fact, in the</p> <p>21 information that I have gave you, you will</p> <p>22 see that I did not know the mine locations</p> <p>23 for many, many samples, but I did happen to</p> <p>24 know the mine location for Vermont for</p> <p>25 several, so that's how I was able to come up</p>	<p>1 that's sort of a strange question.</p> <p>2 Do I consider myself to be an</p> <p>3 expert in using electron microscopy and SAED</p> <p>4 to identify minerals? Yes.</p> <p>5 Q. Okay. Exhibit 19 is a report</p> <p>6 from McCrone Associates where they say,</p> <p>7 "We've examined two groups of samples using</p> <p>8 electron microscopy and selected area</p> <p>9 diffraction to determine the extent of</p> <p>10 amphiboles or serpentine contamination in</p> <p>11 these two groups of samples."</p> <p>12 And then they describe these as</p> <p>13 talc samples from your orebody, being the</p> <p>14 Windsor Mineral company's orebody.</p> <p>15 "The second grade consisted of</p> <p>16 seven samples which were sent to us</p> <p>17 subsequently to be analyzed separately."</p> <p>18 And then it has their general</p> <p>19 conclusions on pages 2, 3, 4 of the report.</p> <p>20 Do you see that?</p> <p>21 MR. CHACHKES: Objection.</p> <p>22 THE WITNESS: It will take me a</p> <p>23 while to read through these five</p> <p>24 pages, but I certainly see the pages.</p> <p>25</p>

65 (Pages 254 to 257)

Melinda Darby Dyar, Ph.D.

Page 258	Page 260
<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. You were asked by Johnson &</p> <p>3 Johnson to evaluate the methodology that</p> <p>4 Dr. Longo and Rigler followed to analyze</p> <p>5 samples of talc to determine whether there's</p> <p>6 asbestos in them or not, correct?</p> <p>7 That was your charge here?</p> <p>8 A. I was asked to evaluate the</p> <p>9 methodology -- methodology -- methodology of</p> <p>10 Drs. Longo and Rigler, yes, that is why we're</p> <p>11 all here.</p> <p>12 Q. If you were asked by Johnson &</p> <p>13 Johnson to analyze both the methodology and</p> <p>14 the conclusions of Walter McCrone Associates</p> <p>15 in this July 1975 report, what information or</p> <p>16 data or materials would you want to see?</p> <p>17 MR. CHACHKES: Objection.</p> <p>18 THE WITNESS: That's kind of a</p> <p>19 strange hypothetical. Because that's</p> <p>20 not enough information in here for me</p> <p>21 to even evaluate what their</p> <p>22 methodology was.</p> <p>23 QUESTIONS BY MR. FINCH:</p> <p>24 Q. Well, they state that they used</p> <p>25 electron microscopes and selected area</p>	<p>1 agreed with their conclusions?</p> <p>2 A. So in my report I referred to</p> <p>3 in -- particularly the Yamate document which</p> <p>4 we've already discussed on this day that says</p> <p>5 two zone axis measurements and an EDS pattern</p> <p>6 are usually enough to identify an asbestos</p> <p>7 mineral.</p> <p>8 But there's no information in</p> <p>9 the very brief, out-of-context document about</p> <p>10 samples that I don't know where they came</p> <p>11 from or whether these were actually used as</p> <p>12 ore for anything having to do with talcum</p> <p>13 powder. I don't know.</p> <p>14 Q. All right. Would you -- one of</p> <p>15 the things, I assume, that you would want to</p> <p>16 look at would be the EDS, EDXA printouts of</p> <p>17 their electron microscopes if they used EDS,</p> <p>18 EDXA to analyze the chemical composition of</p> <p>19 the structures they were looking at.</p> <p>20 Is that one item of data you</p> <p>21 would want to see to evaluate their</p> <p>22 methodology in coming to this report for</p> <p>23 Windsor Mineral?</p> <p>24 MR. CHACHKES: Objection.</p> <p>25 THE WITNESS: So, again, this</p>
Page 259	Page 261
<p>1 diffraction to determine the extent of</p> <p>2 amphiboles or serpentine contamination of two</p> <p>3 groups of talc samples.</p> <p>4 So they describe, at least</p> <p>5 generally, the tools and methodology they are</p> <p>6 using in their July 1975 report, correct?</p> <p>7 MR. CHACHKES: Objection.</p> <p>8 THE WITNESS: I don't know. I</p> <p>9 would have to look at this more</p> <p>10 carefully than just this brief</p> <p>11 inspection, but, for example, if they</p> <p>12 used SAED, did they do two different</p> <p>13 zone axes? I don't know. Perhaps if</p> <p>14 I read -- had the time to sit down and</p> <p>15 read this, I might find that out.</p> <p>16 But all they say is electron</p> <p>17 microscopy. I don't know what that</p> <p>18 means. Does that mean SAED using an</p> <p>19 electron microscope, or does that mean</p> <p>20 they did something else other than</p> <p>21 SAED? Unclear.</p> <p>22 QUESTIONS BY MR. FINCH:</p> <p>23 Q. Okay. What information would</p> <p>24 you want to see in order to evaluate what</p> <p>25 they did and whether -- or whether or not you</p>	<p>1 is kind of an extreme hypothetical. I</p> <p>2 return to the Yamate paper which says</p> <p>3 that to identify asbestos you need two</p> <p>4 SAED patterns and some EDS</p> <p>5 information.</p> <p>6 QUESTIONS BY MR. FINCH:</p> <p>7 Q. Okay. So we'd want to see SAED</p> <p>8 patterns, which are taken at least two</p> <p>9 different zone axes, correct?</p> <p>10 A. Correct.</p> <p>11 Q. You'd want to see EDS</p> <p>12 information, correct?</p> <p>13 A. That's what I just said, yes.</p> <p>14 Q. Would you want to see</p> <p>15 photomicrographs of the structures they were</p> <p>16 examining under the microscope to see what</p> <p>17 you could learn about their morphology or</p> <p>18 aspect ratio?</p> <p>19 MR. CHACHKES: Objection.</p> <p>20 THE WITNESS: All of that</p> <p>21 depends on what the goal of the</p> <p>22 testing is.</p> <p>23 This testing says they found</p> <p>24 amphiboles, but it doesn't -- but</p> <p>25 there's no information here that would</p>

66 (Pages 258 to 261)

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 262</p> <p>1 suggest that they are asbestiform 2 amphiboles. 3 And in fact, you'd think that 4 if it's such a rare thing that they 5 would actually note if it was 6 asbestiform, and it's not noted as 7 such in here. 8 QUESTIONS BY MR. FINCH: 9 Q. Doesn't it say in Table 1 and 10 Table 2 confirmed asbestos visual and then 11 description of sample content of sediment, 12 asbestos? 13 A. It gives the word "visual," 14 which does not instill in me a lot of 15 confidence that it's actually either. Visual 16 of what? Visual of the SAED pattern? Visual 17 of the image they were looking at down the 18 electron microscope. 19 There's -- one wonders if 20 there's more to this document and what the 21 context is, and whether these samples were 22 even used in talcum powder. Can't tell any 23 of that from here. 24 I don't know what the word 25 "low" means, for example.</p>	<p style="text-align: right;">Page 264</p> <p>1 THE WITNESS: I'm not exactly 2 sure how this question is appropriate 3 to my mandate, which was to evaluate 4 the methodology used by someone else. 5 I have not yet been asked to 6 devise my own methodology, and so it's 7 hard for me to make a definitive 8 statement of that. 9 In my report I say that 10 Drs. Longo and Rigler should have 11 followed the Yamate recommendation of 12 two zone axes and an EDS pattern, and 13 I also say that the Su method, which 14 uses PLM, is useful in identifying 15 asbestos. 16 So if I were going to design my 17 own protocol, in vague terms, it would 18 be some combination of those, but 19 that's all I could say without further 20 study. 21 QUESTIONS BY MR. FINCH: 22 Q. Am I correct that you have 23 never designed a protocol for testing talc to 24 determine whether or not it has asbestos 25 fibers in it?</p>
<p style="text-align: right;">Page 263</p> <p>1 Q. Well, would you want to see 2 their count sheets, for example? 3 MR. CHACHKES: Objection. 4 QUESTIONS BY MR. FINCH: 5 Q. To evaluate their methodology 6 and conclusions? 7 MR. CHACHKES: Objection. 8 THE WITNESS: I find this 9 question kind of too hypothetical. If 10 they existed, I would want all the 11 information that they had available. 12 But in particular, I would want the 13 SAED zone axis information and the EDS 14 quantitative information to the extent 15 that that was available in 1975. 16 QUESTIONS BY MR. FINCH: 17 Q. I want you to assume that you 18 are provided with a hundred samples of talc 19 by Johnson & Johnson and asked to evaluate it 20 for the purpose of determining whether or not 21 it contains asbestiform asbestos fibers. 22 What methodology would you use, 23 what would you do step by step to analyze 24 each particular talc sample? 25 MR. FROST: Objection.</p>	<p style="text-align: right;">Page 265</p> <p>1 A. I've designed many, many 2 analytical protocols for a wide range of 3 instrumentation, but it is correct to say 4 that I have never devised a protocol for 5 analyzing asbestos in anything. 6 Q. Okay. And is it correct to say 7 that you have never in your professional work 8 relied on the published protocol that are out 9 there for analyzing the presence of asbestos 10 in anything? 11 A. In my research, I have 12 consistently relied on these tools for the 13 identification of a wide range of minerals. 14 What was your question? 15 But I have never had the need 16 in my professional work to rely on any 17 published protocol for analyzing the presence 18 of asbestos. 19 Q. Okay. Do you draw a 20 distinction in your mind between the tools 21 that a scientist uses to determine the nature 22 of a mineral and the protocol that a 23 scientist follows to determine the nature of 24 a mineral? 25 A. Well, the tools are just the</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 266</p> <p>1 pencils of a -- of a mineralogist, if you 2 will, and the protocol is that you're trained 3 to use the pencils. 4 So I don't really understand 5 the question. 6 Q. Okay. Well, the tools -- would 7 you agree with me that one tool that is 8 useful to determine whether or not there is 9 asbestos in a mineral is a polarized light 10 microscope? 11 A. Yes. 12 Q. Would you agree with me that 13 another tool that is useful to determine 14 whether or not there is asbestos in a mineral 15 is a transmission electron microscope? 16 A. Yes. 17 Q. Would you agree with me that 18 another tool that is useful to determine 19 whether or not there's asbestos in a mineral 20 is a scanning electron microscope? 21 A. Yes. 22 Q. Do you view SAED as a tool or a 23 protocol? 24 A. I view it as a technique. 25 Q. Okay. Do you agree that SAED</p>	<p style="text-align: right;">Page 268</p> <p>1 mineral if it is used in conjunction with 2 other techniques? 3 A. Asbestos in a mineral? I'm not 4 sure what you mean by that. 5 Q. Asbestos in talc. 6 A. No, strictly speaking I'm going 7 to reverse my previous answer. 8 SAED can't tell you whether 9 asbestos is present because SAED cannot tell 10 you the -- anything about the morphology of 11 the particle. SAED can only tell you what 12 the crystal structure is. 13 Q. Again, my question is not 14 whether SAED by itself can tell you 15 definitively whether a particle is asbestos 16 or not. 17 My question is: Is SAED a 18 useful technique that a scientist should 19 follow if they're analyzing a sample of talc 20 and they want to determine whether or not 21 there is asbestos in it or not? 22 A. SAED is useful for answering 23 that question, yes. 24 Q. Is EDS, EDXA useful for 25 answering the question and analyzing a sample</p>
<p style="text-align: right;">Page 267</p> <p>1 is a useful technique for determining the 2 presence of asbestos in a mineral? 3 A. No, because as with all the 4 previous questions, some of these techniques 5 only tell you which mineral species is 6 present. 7 So in order to determine 8 whether something is asbestos, of course, 9 part of the answer is understanding the 10 chemistry, part of the answer is 11 understanding the crystal chemistry, and part 12 of the answer is evaluating mineralogy -- 13 sorry, morphology. 14 So each of these techniques 15 that we've just discussed here treat a 16 different aspect of the definition of 17 asbestos that's given in my report. 18 Q. Okay. And I didn't ask you 19 whether or not SAED is sufficient by 20 itself -- is technique that's sufficient by 21 itself for determining the presence of 22 asbestos in a mineral. 23 I'm asking whether using the 24 technique of SAED is a useful technique for 25 determining the presence of asbestos in a</p>	<p style="text-align: right;">Page 269</p> <p>1 of talc to determine whether or not there's 2 asbestos in it? 3 A. Again, let's be absolutely 4 clear here. EDS only tells you something 5 about the composition, but knowing something 6 about the composition may, in fact, inform 7 the question of whether or not there is one 8 of the six regulated asbestos mineral species 9 present, yes. 10 Q. In order for a scientist to 11 conclude that there is asbestos present in 12 talc, is it your view that he or she should 13 test the sample using EDXA with two zone 14 axes -- excuse me, using EDXA, full stop, 15 SAED with two zone axes, PLM and doing a 16 statistical test on the aspect ratios if 17 there's enough fibers to look at to analyze 18 that? 19 A. If it's -- if it's all done 20 properly, yes. 21 Q. Okay. So the four techniques 22 to determine whether or not talc contains 23 asbestos are EDXA, SAED, PLM, and some kind 24 of statistical test on the aspect ratios to 25 determine whether it's asbestiform or</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 270</p> <p>1 non-asbestiform; is that correct?</p> <p>2 A. It doesn't necessarily have to</p> <p>3 be the aspect ratios, but some kind of</p> <p>4 statistical test on the measurements of the</p> <p>5 particle sizes -- size dimensions, yes.</p> <p>6 Q. Any other technique that you</p> <p>7 regard as necessary to determine whether or</p> <p>8 not talc contains asbestos?</p> <p>9 MR. FROST: Objection. Form.</p> <p>10 THE WITNESS: I think that</p> <p>11 combination of techniques, if done</p> <p>12 properly, which Drs. Longo and Rigler</p> <p>13 don't seem to know how to do, would be</p> <p>14 sufficient to identify impurities that</p> <p>15 occur in talc as being one of the six</p> <p>16 regulated asbestos mineral species,</p> <p>17 yes.</p> <p>18 But only if they're done</p> <p>19 properly. And, of course, my report</p> <p>20 details the many problems with the way</p> <p>21 they were done by Drs. Longo and</p> <p>22 Rigler.</p> <p>23 QUESTIONS BY MR. FINCH:</p> <p>24 Q. Does PLM allow you to</p> <p>25 positively identify asbestos fibers?</p>	<p style="text-align: right;">Page 272</p> <p>1 that there's ten instances where the Longo,</p> <p>2 Rigler reports identify concentrations of</p> <p>3 asbestos by the Blount PLM method that are</p> <p>4 well above the sensitivity limits ISO PLM.</p> <p>5 What do you mean by that?</p> <p>6 A. So those are given in the table</p> <p>7 at the top of page 47.</p> <p>8 So in other words, there's an</p> <p>9 inconsistency here because the Blount PLM</p> <p>10 test, which is supposedly more sensitive than</p> <p>11 the ISO PLM test, registers no asbestos. So</p> <p>12 it's quite an inconsistency here that the</p> <p>13 other technique is finding unusual and</p> <p>14 unreproducible amounts.</p> <p>15 Q. You're talking about the table</p> <p>16 at the top of 47?</p> <p>17 A. Correct.</p> <p>18 Where I'm contrasting the</p> <p>19 Longo, Rigler PLM results with the ones from</p> <p>20 J3.</p> <p>21 Q. Okay. Do you know how much</p> <p>22 time the analysts at J3 spent to analyze each</p> <p>23 sample under PLM versus how much time the</p> <p>24 analysts in Longo's labs spent to analyze the</p> <p>25 samples using PLM?</p>
<p style="text-align: right;">Page 271</p> <p>1 A. If done correctly, it may.</p> <p>2 So here's the problem,</p> <p>3 polarized light microscopy relies on two</p> <p>4 different kinds of information: One</p> <p>5 information is about the dimension of the</p> <p>6 particle and if the particle is bigger than</p> <p>7 about 2.5 microns, it can be seen with PLM.</p> <p>8 So that's one thing.</p> <p>9 And then the other thing is PLM</p> <p>10 relies on refractive index, and generally</p> <p>11 speaking you look at it in two directions.</p> <p>12 So assuming that the particle was big enough</p> <p>13 to see and assuming that the correct series</p> <p>14 of refractive index measurements were made as</p> <p>15 represented by Su who says use 10 to 20</p> <p>16 different refractive index oils and look at</p> <p>17 many different grains, if all of that was</p> <p>18 done properly, then, yes, PLM can potentially</p> <p>19 be used to identify asbestos minerals.</p> <p>20 So, again, it's if done</p> <p>21 properly. And, of course, as I said, if the</p> <p>22 dimensions of the grain are such that they</p> <p>23 can be seen under polarized light -- under</p> <p>24 PLM.</p> <p>25 Q. All right. On page 46 you said</p>	<p style="text-align: right;">Page 273</p> <p>1 A. I have no information on that.</p> <p>2 I don't believe that's stated anywhere in the</p> <p>3 reports.</p> <p>4 Q. Do you have an understanding of</p> <p>5 what is the typical time an analyst would</p> <p>6 spend to identify by PLM asbestos in an</p> <p>7 asbestos-containing bulk material where you</p> <p>8 believe it's likely to be there?</p> <p>9 A. So in other words, if you</p> <p>10 handed me a sample of salt, told me it was</p> <p>11 salt, and then asked me to identify it under</p> <p>12 a polarized light microscope, how long would</p> <p>13 it take me? Not very long.</p> <p>14 Q. 10 to 15 minutes?</p> <p>15 A. Maybe.</p> <p>16 Q. Do you have any understanding</p> <p>17 as to how much material Dr. Longo's lab</p> <p>18 analyzed using the Blount PLM method as</p> <p>19 compared to J3 Resources as reflected in the</p> <p>20 table at the top of page 47?</p> <p>21 A. I don't recall that</p> <p>22 information. I don't recall if it was in the</p> <p>23 report. I wasn't paying attention to how</p> <p>24 much material was there because it's really</p> <p>25 irrelevant. In PLM you're looking at a very</p>

Melinda Darby Dyar, Ph.D.

Page 274	Page 276
<p>1 small area, and so how much material he had</p> <p>2 to start out with is completely irrelevant.</p> <p>3 It's what ended up on the slide and being</p> <p>4 inspected by PLM that would be relevant.</p> <p>5 Q. In your Longo, Rigler, Blount</p> <p>6 PLM weight percentage, what's the denominator</p> <p>7 that you're using for that?</p> <p>8 Is that the material after it's</p> <p>9 been spun out using the Blount method or is</p> <p>10 that before?</p> <p>11 A. Those are just the results in</p> <p>12 the report. I don't recall. Those are your</p> <p>13 numbers. I just tabulated them and put them</p> <p>14 in my report. I don't recall.</p> <p>15 Q. Do you know what an</p> <p>16 aberrational corrective lens is for a</p> <p>17 polarized light microscope?</p> <p>18 A. Yes.</p> <p>19 Q. Can you explain that?</p> <p>20 A. There's different kinds of</p> <p>21 aberration corrections. It's basically a</p> <p>22 piece of glass with optical properties that</p> <p>23 change the appearance of the image that you</p> <p>24 see under the microscope.</p> <p>25 Q. Could the fact that one</p>	<p>1 laboratory spent 15 minutes looking at each</p> <p>2 sample by PLM to determine if they found</p> <p>3 anything that was indicative of an asbestos</p> <p>4 fiber and the other laboratory spent two</p> <p>5 hours per sample, could the time spent affect</p> <p>6 what is found?</p> <p>7 A. You know, as a scientist, I</p> <p>8 don't think in terms of how long a task</p> <p>9 takes. I think in terms of trying to get the</p> <p>10 right answer.</p> <p>11 So as a scientist, it didn't</p> <p>12 even occur to me to look at these reports and</p> <p>13 ask how long something took. I assumed that</p> <p>14 they took enough time to get the answers that</p> <p>15 they did.</p> <p>16 Q. Would you agree with me just</p> <p>17 generally, if you're looking for minute</p> <p>18 amounts of material in a substance, the more</p> <p>19 time you spend looking for it, if it's there,</p> <p>20 the higher likelihood that you are to find it</p> <p>21 than as compared to the less time you spend</p> <p>22 looking for it?</p> <p>23 A. So if you hide a needle in a</p> <p>24 haystack and you search for ten minutes,</p> <p>25 you're probably not going to find the needle,</p>
Page 275	Page 277
<p>1 laboratory used an aberrational corrective</p> <p>2 lens versus a standard lens affect the</p> <p>3 ability to detect asbestos in a sample of</p> <p>4 talc?</p> <p>5 A. Well, it would depend on what</p> <p>6 kind of aberrational microscope it was, and</p> <p>7 it would also depend on how the analysis was</p> <p>8 done.</p> <p>9 So not necessarily, I guess,</p> <p>10 would be my answer to that.</p> <p>11 Q. But it could?</p> <p>12 A. It could or it could not,</p> <p>13 depending on exactly which kind of correction</p> <p>14 lens you were using.</p> <p>15 If you're talking about the</p> <p>16 lens using {sic} in dispersion staining,</p> <p>17 that's not necessarily a more accurate method</p> <p>18 than using a succession of refractive index</p> <p>19 oils.</p> <p>20 Q. Could the amount of time spent</p> <p>21 looking through the sample to determine</p> <p>22 whether or not there was any asbestos</p> <p>23 detected affect the results of one laboratory</p> <p>24 versus another?</p> <p>25 By that mean I mean if one</p>	<p>1 and if you searched for two days, you might</p> <p>2 not find the needle. So it kind of depends</p> <p>3 on the abundance of the impurity that you're</p> <p>4 looking for.</p> <p>5 Q. But do you think --</p> <p>6 A. In that case, the difference</p> <p>7 between two days and ten minutes is not</p> <p>8 significant.</p> <p>9 Q. Have you ever done any analysis</p> <p>10 to determine whether the difference between</p> <p>11 two hours of looking at talc with a PLM will</p> <p>12 make a material difference as compared to</p> <p>13 looking at it for 15 minutes on a per-sample</p> <p>14 basis?</p> <p>15 A. You know, I teach optical</p> <p>16 mineralogy, or have taught frequently. Some</p> <p>17 students can identify a mineral really fast;</p> <p>18 some students take a long time. Both of them</p> <p>19 will get to the right answer eventually.</p> <p>20 So as I said, as a scientist, I</p> <p>21 never think in terms of the time it takes. I</p> <p>22 just think about how good the -- about what</p> <p>23 is necessary to obtain the result needed.</p> <p>24 Time is not a thing that's usually relevant</p> <p>25 to me.</p>

70 (Pages 274 to 277)

Melinda Darby Dyar, Ph.D.

Page 278	Page 280
<p>1 Q. Am I correct that you did not 2 make any analysis of the time the analysts 3 spent with PLM on the samples in the J3 lab 4 versus the Longo lab? 5 A. That's correct, and the reason 6 would be that I do not consider time to be 7 relevant to how good their methodology was. 8 Q. All right. On page 49 you 9 have -- an example of a confusing PLM image 10 is given in Figure 21. 11 A. Correct. 12 Q. Am I correct that Figure 21 is 13 a printout of an image that's in the backup 14 materials to Dr. Longo's report? 15 A. It is one of his dispersion 16 staining images, yes. 17 Q. Okay. You say, "The view at 18 left is pink because it is a dispersion 19 staining image, which is a special way a 20 plate is inserted in the microscope to make 21 the colors more intense and more diagnostic." 22 A. In layman's terms, yes, that's 23 what I say. 24 Q. Why do you conclude that it's a 25 dispersion staining image?</p>	<p>1 your report; is that correct? 2 A. I'd have to look, but -- well, 3 actually, I don't think this is Figure 12. 4 Are we looking at the first 5 one? 6 This is not Image 21. 7 Q. Page 49 of your report. 8 Look at page 49 of your report. 9 A. Oh, yes -- oh, right, but not 10 this. Okay. Yes. 11 Q. Okay. Page 49 of your report 12 has -- in the bottom it has a sample number? 13 A. Yep. 14 Q. Okay. And what is the sample 15 number? 16 A. Well, it's too small for me to 17 read. 18 Q. Okay. I can read it. It says, 19 "M69680-015BL-003, anthophyllite elongation 20 at 400 times." 21 A. Okay. Thank you. 22 Q. All right. Section 13 is -- 23 let's go through it page by page. 24 First of all, it lists the 25 project split number M69680-015BL, correct?</p>
Page 279	Page 281
<p>1 A. Because the background color is 2 pink, and the action of the dispersion lens 3 is usually to increase the colors that are 4 viewed. 5 Q. Do you know what an elongation 6 image is? 7 A. Yes. 8 Q. What is an elongation image? 9 A. An elongation image is when you 10 use -- you rotate the microscope to get 11 the -- the image to coincide with the maximum 12 extent of reflective index. 13 Q. And can an elongation image be 14 done without dispersion staining? 15 A. Yes. 16 Q. And it typically is done 17 without dispersion staining, correct? 18 A. Correct. 19 MR. FINCH: Can I have the next 20 document? 21 (Dyar Exhibit 22 marked for 22 identification.) 23 QUESTIONS BY MR. FINCH: 24 Q. What are we up to? 22. 25 So this is Figure 21 out of</p>	<p>1 A. Correct. 2 Q. Analyzed by Paul Hess on 3 12/11/2018? 4 A. That information isn't here, 5 but... 6 Q. This should be -- do you have 7 the first page of the -- keep going 8 backwards. 9 A. Ah. This, yes. Okay. Got it. 10 Q. All right. So sample 11 M69680-015BL is the sample -- M69680-015BL, 12 that's the sample -- it's from the same 13 sample that you're looking at in Figure 21 in 14 your expert witness report. 15 Right, ma'am? 16 A. If that's what the label says, 17 then, yes. 18 Q. Okay. So the first page of 19 Exhibit 22 -- is that 22, ma'am? 20 A. Yes. 21 Q. It says Section 13. 22 The second is a page entitled 23 "PLM Analysis" that has the sample listed, 24 correct? 25 A. Here?</p>

71 (Pages 278 to 281)

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 282</p> <p>1 Q. Yes.</p> <p>2 A. Yeah.</p> <p>3 Q. What is the third page of</p> <p>4 Exhibit --</p> <p>5 A. It's an image.</p> <p>6 Q. It's an image with a dispersion</p> <p>7 staining, correct?</p> <p>8 MR. CHACHKES: Just to make</p> <p>9 sure we're on the -- literally the</p> <p>10 same page, are you looking at the red</p> <p>11 page or the gold, black page?</p> <p>12 MR. FINCH: I'm looking at the</p> <p>13 gold and black page. Yeah, so you're</p> <p>14 not on the same page.</p> <p>15 THE WITNESS: Yep. Yep.</p> <p>16 MR. FINCH: I'm looking at the</p> <p>17 gold and black page. This is --</p> <p>18 MR. CHACHKES: Not that page.</p> <p>19 MR. FINCH: This page.</p> <p>20 MR. CHACHKES: You're counting</p> <p>21 from different numbers.</p> <p>22 THE WITNESS: Oh, got it.</p> <p>23 Okay.</p> <p>24 QUESTIONS BY MR. FINCH:</p> <p>25 Q. This is M69680-015BL-001.</p>	<p style="text-align: right;">Page 284</p> <p>1 yes.</p> <p>2 Q. That's what it says right on</p> <p>3 the document, right?</p> <p>4 MR. CHACHKES: Now what page</p> <p>5 are we on?</p> <p>6 MR. FINCH: I'm on the page</p> <p>7 that is identical to the page that's</p> <p>8 Figure 21 in her expert witness</p> <p>9 report.</p> <p>10 THE WITNESS: That's what it</p> <p>11 says, elongation, yes.</p> <p>12 MR. CHACHKES: No, you're</p> <p>13 looking at your report. I'm saying</p> <p>14 which -- what page are you looking at</p> <p>15 in that Section 13?</p> <p>16 MR. FINCH: Well, 1, 2, 3, 4,</p> <p>17 5, 6, 7, 8, 9, 10, 11, 12, 13.</p> <p>18 13th page of Section 13 --</p> <p>19 MR. CHACHKES: Okay.</p> <p>20 MR. FINCH: -- of Exhibit 22.</p> <p>21 THE WITNESS: Ah, this lovely</p> <p>22 grain, yes.</p> <p>23 MR. FINCH: If you look on the</p> <p>24 Elmo, I've got it.</p> <p>25 THE WITNESS: Yeah, that's</p>
<p style="text-align: right;">Page 283</p> <p>1 That's dispersion staining, correct?</p> <p>2 A. Well, when you put -- you can</p> <p>3 use different wave plates to change the</p> <p>4 color. Often dispersion staining images are</p> <p>5 pink. It's also possible to have that color</p> <p>6 from a different kind of wave plate. So I'm</p> <p>7 not -- I don't think that these -- in some</p> <p>8 cases they were specifically labeled as such.</p> <p>9 I don't happen to recall what this one was</p> <p>10 labeled as.</p> <p>11 Q. Well, you said in your report</p> <p>12 that sample M69680-015BL-003 is a dispersion</p> <p>13 staining image, correct?</p> <p>14 You say that at page 49. "The</p> <p>15 view of the left is pink because it is a</p> <p>16 dispersion staining image," right?</p> <p>17 A. I do see that, but the same</p> <p>18 thing could be true with the wave plate. So</p> <p>19 it doesn't really matter whether it's a</p> <p>20 dispersion staining image or a -- just a</p> <p>21 normal wave plate image.</p> <p>22 Q. This is --</p> <p>23 A. You interpret them differently.</p> <p>24 Q. This is an elongation image?</p> <p>25 A. That's what you're telling me,</p>	<p style="text-align: right;">Page 285</p> <p>1 right. I have it in my report. I</p> <p>2 know what it looks like.</p> <p>3 Here, I'll just look at it on</p> <p>4 Alex.</p> <p>5 QUESTIONS BY MR. FINCH:</p> <p>6 Q. And so that is an anthophyllite</p> <p>7 elongation image, correct?</p> <p>8 A. There is no way that's what</p> <p>9 that is.</p> <p>10 Q. And there is -- there's no</p> <p>11 indication that this is an image taken with</p> <p>12 dispersion staining, correct, on the picture</p> <p>13 that's large enough to seen?</p> <p>14 A. No, so I might have miswritten</p> <p>15 that it's a dispersion staining image, but</p> <p>16 that doesn't change the fact that that is not</p> <p>17 anthophyllite.</p> <p>18 Q. So you were incorrect when you</p> <p>19 said this was a dispersion staining image; is</p> <p>20 that true?</p> <p>21 MR. LOCKE: Objection.</p> <p>22 THE WITNESS: I honestly don't</p> <p>23 recall.</p> <p>24 The focus of analyzing this</p> <p>25 particular image has nothing to do</p>

72 (Pages 282 to 285)

Melinda Darby Dyar, Ph.D.

Page 286	Page 288
<p>1 with whether it's a dispersion image 2 or not. It has to do with the 3 ridiculousness of there happening to 4 be an amphibole grain that happens to 5 be exactly the same length as a talc 6 particle and happens to line up 7 exactly along the edge of the talc 8 particle. That's the point of 9 including this figure in the document. 10 So whether or not it's a 11 dispersion staining image is real 12 pretty irrelevant. 13 QUESTIONS BY MR. FINCH: 14 Q. Now, isn't it true that in the 15 previous two images they take a look at the 16 same material from two different rotations? 17 One of it -- 18 A. Yes. 19 Q. And wouldn't it be the case 20 that if it were a talc particle curled up on 21 edge, it would look different in the 22 M69680-015BL-003? 23 A. Well, these two images were not 24 taken with the same wave plate. Regardless 25 of whether it was dispersion or not, they're</p>	<p>1 referring to? The page in front of the 2 elongation image? Page 12? 3 A. Yeah, it says it's a dispersion 4 staining image, so I guess we have to accept 5 that that's what -- that is what they say it 6 is. 7 But the other one is not -- 8 clearly not the same wave plate, so one would 9 conclude that it was a different accessory. 10 Q. "The other one." What's the 11 other one you're referring to? 12 A. The ones with the pink 13 background. 14 Because accessories are used in 15 polarizing light microscopes to intensify the 16 colors and change them, and so sometimes the 17 background color is diagnostic of the use of 18 a wave plate. 19 Q. So you're saying it's your 20 opinion that the images on pages 11, 12 -- 21 excuse me, 10, 11, 12 and 13 of Exhibit 22 22 are different structures? 23 A. Well, they're obviously 24 different grains. 25 Well, that's not true. In one</p>
Page 287	Page 289
<p>1 not taken -- obviously the colors are 2 different, so they weren't taken under the 3 same conditions, so the colors would be 4 different. 5 Q. What I'm asking you is, if it 6 were in fact talc rolled up as opposed to 7 anthophyllite, wouldn't it be the case it 8 would appear differently between the image 9 I'm showing you on the Elmo now and the 10 rotated image that's one page behind it? 11 A. Only if the same wave plate was 12 used in both images. 13 Q. And you don't know whether 14 that's true or not, do you? 15 A. One of them says "perpendicular 16 dispersion" and the other one says 17 "elongation," and I don't recall from the 18 report specifically which ones of these is 19 which. I mean -- but clearly they're not 20 under the same conditions. Because when you 21 put a wave plate under a microscope, the 22 colors intensify as seen in the pink 23 background, and this image clearly does not 24 have any kind of wave plate. 25 Q. Which is the "this" you're</p>	<p>1 case it's the same grain rotated in two 2 directions. Let's see, where is that one? 3 I'm lost in page space. These 4 aren't numbered, so I don't know which ones 5 you're referring to. 6 Q. Well, let's -- we established 7 that the elongation image is the 13th page of 8 Exhibit 22, right? 9 A. Okay. This is page 13, yes. 10 Q. All right. The page before 11 that is the same sample, anthophyllite 12 perpendicular dispersion, correct? 13 A. Yes. 14 Q. And then they rotate the 15 sample, and it is the same sample, 16 anthophyllite parallel dispersion? 17 A. Well, that's the way it's 18 labeled, yes. 19 Q. So if it were in fact the same 20 sample they've turned two different ways, 21 would you agree with me that that can't be 22 talc rolled up on its side? 23 A. No. 24 Q. Why not? 25 A. Because the optical properties</p>

73 (Pages 286 to 289)

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 290</p> <p>1 of talc, when you look down on the sheets, 2 are different than the optical properties of 3 talc when you look perpendicular to the 4 sheets. 5 Q. What's a cross-polar? 6 A. A cross-polar is a piece of 7 glass that is manufactured in such a way that 8 light vibrating in one direction -- only one 9 direction gets -- passes through, like a 10 polarizing pair of sunglasses. 11 Q. On page 48 and 49 of your 12 report, you state that the Su 2003 paper 13 requires looking at 10 to 20 grains? 14 A. I believe I quote from the Su 15 document in here somewhere, yes. 16 Q. It says, "After 10 to 20 fibers 17 are examined in this way, 10 to 20 fibers 18 were examined in the extinction position." 19 What's the difference between 20 the extinction position and the original 21 position? 22 A. So extinction is when the 23 microscope stage is rotated so the grain 24 becomes dark. 25 It's on page 47, is where the</p>	<p style="text-align: right;">Page 292</p> <p>1 determination that the images that you 2 examined contained cleavage fragments and not 3 fibers? 4 A. Because in my career I've 5 looked at hundreds of thousands of cleavage 6 fragments of minerals under a microscope, and 7 I know what they look like. 8 The -- and I can consistently 9 identify a cleavage fragment based on having 10 looked at hundreds of thousands of cleavage 11 fragments in my career. 12 Q. So your opinion that what 13 Dr. Longo's analysts are calling bundles of 14 asbestos fibers are in fact cleavage 15 fragments is based on your looking at 16 hundreds of thousands of cleavage fragments 17 under a microscope throughout your career. 18 That's what it's based on, 19 right? 20 A. That, and the research that I 21 did, some of the images that are included in 22 my report such as -- oh, let's see. They're 23 on the morphology section. 24 So, for example, the paper by 25 Campbell, et al., 1977, gives examples of</p>
<p style="text-align: right;">Page 291</p> <p>1 quote is from Su. 2 Q. Uh-huh. 3 A. And it says pretty clearly, 4 "After 10 to 20 fibers are examined in this 5 way, the fiber with the longest is" -- the 6 longest must be refractive index -- "is 7 assumed to exhibit the refractive index 8 closest to N alpha." 9 But again, there's -- I don't 10 recall any information in either of these 11 reports that says that they used -- they 12 examined 10 to 20 fibers. 13 Q. Are there any PLM analyses that 14 Dr. Longo's lab performed that you would 15 agree do show asbestos fibers? 16 A. No. 17 Q. Not a single one? 18 A. No, because let's recall that 19 polarized light microscopy can tell you 20 something about the composition, if properly 21 done, and something about the morphology. 22 And all of the images that I examined contain 23 what I consider to be cleavage fragments, not 24 fibers. 25 Q. Okay. How did you make the</p>	<p style="text-align: right;">Page 293</p> <p>1 asbestiform versus non-asbestiform particles. 2 The paper by Gunther in 2010 3 gives examples of asbestiform and 4 non-asbestiform particles. 5 The paper by Harper in 2010 6 gives examples of what asbestiform and 7 non-asbestiform particles look like. 8 The paper by Pierce in 2017 9 gives examples of what cleavage fragments 10 look like. 11 So I would say that I rely on 12 my background of identifying cleavage 13 fragments, along with careful review of the 14 peer-reviewed literature for what constitutes 15 a cleavage fragment, to make my judgment 16 about what is in these samples. 17 MR. FINCH: Lizzy, can I have 18 the pictures? You know, the redacted 19 pictures? 20 QUESTIONS BY MR. FINCH: 21 Q. So am I correct that you can 22 tell by looking at a photomicrograph whether 23 something is a bundle or a cleavage 24 fragment -- 25 MR. CHACHKES: Objection.</p>

Melinda Darby Dyar, Ph.D.

Page 294	Page 296
<p>1 QUESTIONS BY MR. FINCH: 2 Q. -- based on your expertise and 3 your judgment? 4 A. That's not what I said. 5 I said I have identified 6 hundreds of thousands of cleavage fragments 7 in my career. I have very little experience 8 looking at amphibole bundles in thin section, 9 which is why I referred to the literature to 10 find what those images look like. 11 Q. So you have very little 12 experience of identifying amphibole bundles, 13 correct? 14 MR. LOCKE: Objection. 15 MR. CHACHKES: Objection. 16 THE WITNESS: That's what I 17 said. 18 QUESTIONS BY MR. FINCH: 19 Q. You have very little experience 20 in looking for asbestos fibers under a 21 polarized light microscope, correct? 22 A. I have looked at asbestos 23 fibers under a polarized light microscope in 24 the course of teaching for many years. 25 Q. How many times?</p>	<p>1 Q. -- of the particles? 2 Okay. But you just told me 3 that you had very little experience in 4 reviewing images of asbestiform asbestos 5 bundles under a polarized light microscope or 6 any other kind of light -- any other kind of 7 microscope; is that correct? 8 MR. CHACHKES: Objection. 9 THE WITNESS: Boy, I don't 10 think of it as reviewing images. I've 11 looked down a microscope plenty of 12 times at asbestos. 13 In my experience, most of the 14 asbestos I've looked at has not been 15 bundles. 16 QUESTIONS BY MR. FINCH: 17 Q. And my question is: How many 18 times have you looked down a microscope at 19 asbestos fibers? 20 Is it more than a hundred? 21 A. Well, now you're changing the 22 question. Before it was about bundles, and 23 now it's about fibers. 24 How many times have I looked at 25 asbestos under a microscope --</p>
Page 295	Page 297
<p>1 A. Oh, we covered the amphibole 2 minerals in mineralogy as a routine thing. I 3 think I've taught mineralogy 20 times, so 4 that would be 20 weeks of my life spent 5 teaching what kind of -- what amphiboles look 6 like. 7 Q. How about time spent analyzing 8 structures to determine whether or not they 9 are asbestiform asbestos bundles versus 10 something else? 11 How much time have you spent on 12 a regular basis as part of your academic 13 career doing that? 14 A. Well, let's go back to my 15 report for a minute and remember that the key 16 methodology for distinguishing between 17 asbestiform and non-asbestiform minerals is 18 by careful analysis of the populations based 19 on the dimensions of the particles. 20 So that is -- that 21 identification is not something that we would 22 do in mineralogy. 23 Q. You're talking about the 24 statistical analysis -- 25 A. Correct.</p>	<p>1 Q. Yes. 2 A. -- when I knew it was asbestos 3 from independent means, and I had a 4 macroscopic hand sample, and I myself had 5 prepared the thin section for my class? 6 Literally hundreds. 7 Q. How about when you're 8 attempting to determine what it is, whether 9 it's asbestos or not? 10 A. I think we've already 11 established that I was not asked to do 12 testing in this case, and so I have not 13 looked at any -- any of the talc samples, 14 period. 15 Q. No, my question is: Ever in 16 your career, have you attempted to identify 17 asbestos fibers in a substance where you 18 didn't know what it was? 19 A. No. 20 But that's pretty similar to 21 the way Drs. Longo and Rigler treat their 22 analyses as well, because they presume that 23 everything they look at that's a particle is 24 either a bundle or a frag -- sorry, a bundle 25 or a fiber. There's no case in their notes</p>

75 (Pages 294 to 297)

Melinda Darby Dyar, Ph.D.

Page 298	Page 300
<p>1 where they -- well, it might be a few, where 2 they say something is a cleavage fragment. 3 But they seem to only identify things as one 4 or the other. 5 MR. FINCH: I'll object and 6 move to strike everything after the 7 word "no." 8 QUESTIONS BY MR. FINCH: 9 Q. All right. Let's -- well, 10 actually, there's a few more technical things 11 before we get to this, so... 12 On page 50 and 51 of your 13 report, you fault Dr. Rigler and Longo for 14 not using point counting to estimate the 15 concentration of asbestos by PLM, correct? 16 A. Correct. I found no 17 information in their report to indicate they 18 use point counting. 19 Q. Okay. And you're relying on 20 ISO 22262-1 for your conclusion that point 21 counting is a methodology they should have 22 followed to estimate asbestos by weight? 23 A. No, I'm relying on the quote 24 from ISO 2262 {sic} to say that the accuracy 25 of a point count is dependent on the number</p>	<p>1 It's possible that that quote 2 comes from a different ISO document. I'd 3 want to look that up. 4 Q. Is it possible that it comes 5 from ISO 22262-2? 6 A. Yeah, let's take a look. 7 Q. ISO 22262-2, page 23. 8 A. Interestingly, there are no 9 page numbers in this document. 10 Q. You have Dyar 5? 11 A. Yeah. 12 MR. CHACHKES: I think the page 13 numbers were cut off on our copies. 14 MR. FINCH: Oh. 15 QUESTIONS BY MR. FINCH: 16 Q. It's Section 14.2.3.4. 17 A. Got it. Ah, yes, this is where 18 the point counting is. 19 Okay. Now we are all literally 20 on the same page. 21 Q. Okay. Now, the reference that 22 you have in your report on page 50 and 51 is 23 incorrect, and it should be to ISO 22262-2? 24 A. Right. So the 1 should be a 2. 25 Q. At page 23?</p>
Page 299	Page 301
<p>1 of grains counted. That is the context in 2 which that statement is made. 3 Q. Okay. You're referring to -- 4 your citation is to ISO 22262-1, page 29, 5 right? 6 A. No, page 50 to 51 where I say, 7 "It is well-recognized that the accuracy of a 8 point count depends on the number of grains 9 counted. This is acknowledged in ISO 10 22262-2, which says," et cetera, et cetera. 11 Q. All right. Let's get ISO 12 22262-1. 13 A. So that should be on page 29, 14 that quote. 15 Q. We're on page 29 of ISO 16 22262-1, is that quote. 17 A. That's what it says. It looks 18 like there might be an error in that. 19 Q. Isn't the quote that you're 20 talking about found on page 23? 21 A. Yeah, that might have been a 22 typo. Although I don't see it on page 23. 23 Q. Let's see. 24 A. Let's see if we can find it 25 here. Point counting.</p>	<p>1 A. In the footnote, yes. 2 Q. Right. Okay. 3 Do you agree with me that talc 4 particles and any accessory minerals found in 5 talc can have different sizes? 6 A. Certainly. 7 Q. Can they have different 8 thicknesses? 9 A. Certainly. 10 Q. Can they have different 11 densities? 12 A. What do you mean, "can they 13 have different densities?" 14 Q. Can the talc particles and the 15 accessory minerals have different densities? 16 A. Certainly. 17 Q. Can different accessory 18 minerals have different densities? 19 A. They may. 20 Q. Can talc particles have 21 different thicknesses from other talc 22 particles? 23 A. Yes. Or they could be the 24 same. 25 When you make a grain mount,</p>

76 (Pages 298 to 301)

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 302</p> <p>1 you have no guarantees of what thicknesses of 2 anything are. 3 Q. And would you agree that the 4 point counting methodology that ISO 22262 5 refers to -- refers you back to ISO 22262-1 6 to describe how to do point counting? 7 A. I don't see that right here. 8 You want to tell me where it 9 says that? 10 Q. I misspoke. I'm sorry. 11 Section 14.2-3-4 is where it 12 talks about "the statistical reliability of a 13 point count for determination of asbestos 14 depends on the number of asbestos points, not 15 on the total nonempty points examined." 16 That's the quote you have -- 17 A. That's the quote. 18 Q. -- in your report? 19 A. Yes. 20 Q. Okay. And the determination of 21 amphibole in talc is found on page 29 of ISO 22 22262-2, correct? 23 MR. CHACHKES: So we don't have 24 page numbers. 25 MR. FINCH: Page -- it's 16.3.</p>	<p style="text-align: right;">Page 304</p> <p>1 relative projected areas occupied by 2 different particle species on a microscope 3 slide. The integrated relative volumes of 4 different particle species can be calculated 5 from a conventional point count, but only if 6 the particles are all of the same thickness. 7 If the densities of the various particle 8 species are known, the relative weights of 9 the different particle species can be 10 calculated. However, conventional point 11 counting does not produce correct results 12 when applied to the determination of the 13 proportion of asbestos in a mixture of 14 particles with a wide range of different 15 thicknesses and different densities." 16 Did I read that correctly? 17 A. You did. 18 So I think the point here is 19 twofold. There's not -- there's very little 20 information in the Longo and Rigler reports 21 about the PLM procedures used. And in fact, 22 in most cases when we do this in the 23 laboratory, we sieve the samples so the 24 particles are all the same size. 25 So one normal, logical</p>
<p style="text-align: right;">Page 303</p> <p>1 16.3. 2 THE WITNESS: Yep. 3 QUESTIONS BY MR. FINCH: 4 Q. Okay. This talks -- 5 A. That describes a centrifuge 6 procedure, yes. 7 Q. And then it refers you back. 8 It says, "Quantify any asbestiform amphibole 9 in the centrifugate by the point counting 10 procedure specified in 14.2.3," right? 11 A. Of this document, yes. 12 Q. Yes. Of ISO 22262-2. 13 A. Which is the minimum of 20 14 asbestos points or the equivalent of 13,000 15 nonempty points. That's what it's referring 16 to, yes. 17 Q. Right. 18 But if you go to the beginning 19 of Section 14.2.3, that's the section that 20 refers you back to point counting by PLM or 21 SEM that's found on page 20 of the exhibit. 22 It's the beginning of 14.2.3. 23 A. Yes. 24 Q. All right. What it states is, 25 "Conventional point counting determines the</p>	<p style="text-align: right;">Page 305</p> <p>1 assumption would be that they sieve their 2 particles before they did the PLM analysis. 3 It doesn't say that they did not; it doesn't 4 say that they did. There's not just enough 5 information to know if that's what they did. 6 Q. Isn't it true that 7 Section 14.2.3 that I just read you said that 8 point counting is not accurate if the -- to 9 determine the proportion of asbestos in a 10 mixture of particles with a wide range of 11 different thicknesses and different 12 densities? 13 A. That is indeed what the 14 document says. And what I'm telling you is 15 that it's also possible that the data in the 16 Longo, Rigler reports were all from a sieved 17 sample which were, in fact, the same grain 18 size, in which case you would be able to 19 extract useful information out of it. 20 But the germane point here is 21 what's in my report, and that is that the 22 Longo and Rigler analysts didn't do any of 23 this. They just used visual estimates rather 24 than point counting. And they say in their 25 deposition that they used -- compare visual</p>

Melinda Darby Dyar, Ph.D.

Page 306	Page 308
<p>1 comparisons against unspecified and 2 unregulated weight percent standards. 3 But the results of those are 4 really un -- different from the ones from TEM 5 and, therefore, I consider them to be 6 unreliable. 7 MR. CHACHKES: Incidentally, 8 we've been going over a little over an 9 hour, if you reach a wrapping-up 10 point. 11 MR. FINCH: Two more questions, 12 and then we'll stop for a break. 13 MR. CHACHKES: Always two. 14 QUESTIONS BY MR. FINCH: 15 Q. But you have no information 16 about whether or not they had sieved the 17 samples so that all the particles were of the 18 same thickness and the same density before 19 analyzing them, correct? 20 A. Correct. 21 Q. And ISO 22262-2, 22 Section 14.2.3, says that point counting does 23 not produce correct results when the asbestos 24 is in a mixture of particles with a wide 25 range of different thicknesses and different</p>	<p>1 Point counting is not just used 2 in the asbestos industry. Point counting is 3 a time-honored geologic technique that's been 4 used for probably a hundred years. 5 MR. FINCH: Let's take a break. 6 VIDEOGRAPHER: All right. The 7 time is 4:58 p.m. Off the record. 8 (Off the record at 4:58 p.m.) 9 VIDEOGRAPHER: Okay. We are 10 back on the record. The time is 11 5:32 p.m. 12 QUESTIONS BY MR. FINCH: 13 Q. Good afternoon, Professor Darby 14 Dyar. 15 At page 53 of your report -- 16 this is Exhibit 2 to your deposition, your 17 expert witness report. 18 A. Sorry, what page is that again? 19 Q. 53. 20 A. I'm there. 21 Q. All right. On page -- at 22 Figure 23 A, images of non-asbestiform 23 particles from Gunther 2010. 24 Do you see that? 25 A. Yes.</p>
Page 307	Page 309
<p>1 densities, correct? 2 A. But, sir, your point is moot 3 because the point I make in my report is that 4 they didn't even use point counting. So 5 regardless of whether they sieved the samples 6 or not, they didn't do point counting, so 7 it's unclear to me why this is even relevant. 8 Q. Isn't one reasonable 9 interpretation of ISO 22262-2 is that you're 10 not supposed to do point counting if you're 11 analyzing asbestos found in a material with a 12 wide range of different thicknesses and 13 different densities? 14 A. No, because it would be 15 entirely possible to sieve the samples to 16 make sure they were all the same grain size. 17 Q. Does it say anywhere in ISO 18 22262-2 to sieve all the samples so that 19 they're the same particle and grain size? 20 A. It doesn't need to say that. 21 It says that if they are a different grain 22 size, you won't get good results. So that 23 implies that if you wanted to get good 24 results, you would sieve the samples, which 25 is the standard protocol.</p>	<p>1 Q. Those are images taken from the 2 paper that you and I looked at earlier today, 3 Mickey Gunther's 2010 paper entitled 4 "Defining Asbestos Differences Between the 5 Built and Natural Environments"? 6 A. Mickey's written a lot of 7 papers, but if that's what I say, then that's 8 the one I reference, yes. 9 Q. Well, you referred to Gunther 10 2010. I'm just -- 11 A. Well, hang on. Let's take a 12 look here. 13 Yes. So between -- yep, that's 14 it. Yep. 15 Q. Okay. 16 A. Do you want me to pull that 17 out? 18 Q. No. No. No. 19 A. That is indeed where those 20 images came from. 21 Q. Those images came from what we 22 have marked to our deposition as exhibit -- 23 your Deposition Exhibit 11, correct? 24 A. Yeah. Might turn the page, I'm 25 sure. Yeah, they're in there.</p>

78 (Pages 306 to 309)

Melinda Darby Dyar, Ph.D.

Page 310	Page 312
<p>1 Q. Okay. Were you aware at the</p> <p>2 time that Mr. Gunther wrote this paper that</p> <p>3 he was serving as an expert witness for the</p> <p>4 RT Vanderbilt talc company and issuing expert</p> <p>5 reports that called the materials that were</p> <p>6 found in Gouverneur talc, Gouverneur,</p> <p>7 New York, talc, non-asbestiform cleavage</p> <p>8 fragments as opposed to asbestos --</p> <p>9 asbestiform fibers?</p> <p>10 MR. CHACHKES: Objection.</p> <p>11 THE WITNESS: No, I was not</p> <p>12 aware of any of that.</p> <p>13 QUESTIONS BY MR. FINCH:</p> <p>14 Q. Are you aware that there has</p> <p>15 been an epidemic of mesothelioma from</p> <p>16 employees of the Gouverneur talc mine in and</p> <p>17 around the -- who were employed by the</p> <p>18 Gouverneur talc mine by RT Vanderbilt?</p> <p>19 MR. LOCKE: Objection.</p> <p>20 THE WITNESS: No, I'm not aware</p> <p>21 of that.</p> <p>22 MR. FROST: Objection.</p> <p>23 QUESTIONS BY MR. FINCH:</p> <p>24 Q. Are you aware that the EPA</p> <p>25 Region 9 has criticized Dr. Gunther and</p>	<p>1 its mission statement is?</p> <p>2 MR. CHACHKES: Objection.</p> <p>3 Form.</p> <p>4 THE WITNESS: No, I have no</p> <p>5 knowledge of that.</p> <p>6 QUESTIONS BY MR. FINCH:</p> <p>7 Q. You've never heard of Exponent</p> <p>8 or ChemRisk before?</p> <p>9 A. No.</p> <p>10 Q. Are you familiar with the</p> <p>11 terminology "doubt science" or "distraction</p> <p>12 science"?</p> <p>13 MR. CHACHKES: Objection.</p> <p>14 THE WITNESS: Never heard that</p> <p>15 term.</p> <p>16 QUESTIONS BY MR. FINCH:</p> <p>17 Q. On page 53 of your report you</p> <p>18 say, "Bundles occur as separable groups of</p> <p>19 parallel fibers with splayed ends and matted</p> <p>20 masses as seen in Figure 23 B," as in</p> <p>21 basketball, right?</p> <p>22 A. Yes.</p> <p>23 Q. Do you agree with me that</p> <p>24 bundles do not have to have splayed ends?</p> <p>25 A. All I know is that in ISO</p>
Page 311	Page 313
<p>1 Mr. Lee's analysis of the distinction between</p> <p>2 asbestiform and non-asbestiform?</p> <p>3 MR. FROST: Objection.</p> <p>4 MR. CHACHKES: Objection.</p> <p>5 THE WITNESS: No, I'm not aware</p> <p>6 of that.</p> <p>7 And I will also point out that</p> <p>8 in my report I give examples of</p> <p>9 non-asbestiform particles from other</p> <p>10 sources such as Campbell 1977 and --</p> <p>11 and Pierce 2017.</p> <p>12 QUESTIONS BY MR. FINCH:</p> <p>13 Q. All right. Were you aware that</p> <p>14 Pierce's paper was -- are you aware that</p> <p>15 Ms. Pierce is an employee --</p> <p>16 MR. FINCH: Is it Exponent or</p> <p>17 ChemRisk?</p> <p>18 MR. CHACHKES: Are you aware?</p> <p>19 MR. FINCH: I am, but I'm</p> <p>20 50-some years old, and remembering</p> <p>21 everything off the top of my head</p> <p>22 isn't as easy as it used to be.</p> <p>23 QUESTIONS BY MR. FINCH:</p> <p>24 Q. Are you aware of the nature of</p> <p>25 the entity that employs Ms. Pierce and what</p>	<p>1 22262-1, bundles are described as structures</p> <p>2 composed of parallel, smaller diameter fibers</p> <p>3 attached along these -- along their lengths.</p> <p>4 I think the point is that</p> <p>5 Drs. Longo and Rigler don't define what a</p> <p>6 bundle is either, so it's unclear what</p> <p>7 they -- what they mean when they make those</p> <p>8 assignments.</p> <p>9 Q. All right. In page 5 of ISO</p> <p>10 22262-1, Section 2.29?</p> <p>11 A. Yeah, I think I stole one of</p> <p>12 yours.</p> <p>13 Section 2 point what?</p> <p>14 Q. 29, 2.29 in the definitions.</p> <p>15 A. Uh-huh.</p> <p>16 Q. It says -- it has a definition</p> <p>17 of fiber bundle, correct?</p> <p>18 A. Which is exactly the definition</p> <p>19 I gave, I believe, yes.</p> <p>20 Q. Well, in your report you say</p> <p>21 "bundles occur as separable groups of</p> <p>22 parallel fibers with splayed ends and matted</p> <p>23 masses."</p> <p>24 And my question to you was: Do</p> <p>25 you agree that fiber bundles do not always</p>

Melinda Darby Dyar, Ph.D.

Page 314	Page 316
<p>1 exhibit splayed ends?</p> <p>2 A. You know, I've not been called</p> <p>3 upon to make that judgment call, so I can't</p> <p>4 say.</p> <p>5 Q. Will you agree with me that in</p> <p>6 the definition of fiber bundle on page 5,</p> <p>7 Section 2.29 of ISO 22262-1, it states, "A</p> <p>8 fiber bundle may exhibit diverging fibers at</p> <p>9 one or both ends"?</p> <p>10 A. Yes, it does say -- it does say</p> <p>11 that, yes.</p> <p>12 Q. Okay. And you would agree with</p> <p>13 me that "may" does not mean "always"?</p> <p>14 A. Correct.</p> <p>15 But I did not say that bundles</p> <p>16 are defined as. I just said that's how they</p> <p>17 occur. Very important distinction.</p> <p>18 Q. And you would agree with me --</p> <p>19 would you agree with me that you can have a</p> <p>20 bundle of asbestos fibers without splayed</p> <p>21 ends at either end of the bundle?</p> <p>22 MR. LOCKE: Objection. Asked</p> <p>23 and answered.</p> <p>24 THE WITNESS: The definition in</p> <p>25 ISO 22262 makes a note that says that.</p>	<p>1 from counting criteria into characteristics</p> <p>2 for fibers and bundles.</p> <p>3 Q. The section is entitled</p> <p>4 "Morphology," correct?</p> <p>5 A. Yes.</p> <p>6 Q. And it lists A, B and C,</p> <p>7 correct?</p> <p>8 A. Yes, but it says "generally</p> <p>9 recognized." It doesn't say "always</p> <p>10 recognized."</p> <p>11 Q. And would you agree with me</p> <p>12 that it doesn't say that all of these</p> <p>13 characteristics have to be present in order</p> <p>14 for it to be morphology consistent with</p> <p>15 asbestos?</p> <p>16 A. It doesn't say that -- it's not</p> <p>17 clear. The document itself is not clear.</p> <p>18 Q. Are you aware of any -- other</p> <p>19 than the statistical testing using the aspect</p> <p>20 ratio we'll get to it in a minute, are you</p> <p>21 aware of any objective way to determine</p> <p>22 whether or not a structure you're looking at</p> <p>23 is a bundle or a cleavage fragment in terms</p> <p>24 of something you can measure using a tool or</p> <p>25 a technique of --</p>
Page 315	Page 317
<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. It makes a note that it may</p> <p>3 have splayed ends. It also may not have</p> <p>4 splayed ends, too, correct?</p> <p>5 A. That's correct.</p> <p>6 Q. All right. And in</p> <p>7 Section 7.2.3.7.1 of the same document,</p> <p>8 page 22?</p> <p>9 A. 7.2.3 -- yeah, got it.</p> <p>10 Q. It has a description of</p> <p>11 morphology for -- "morphology that is</p> <p>12 characteristic of asbestos is as follows,"</p> <p>13 and then it has a description of the</p> <p>14 morphology characteristics in laboratory</p> <p>15 samples for PLM identification of the fiber</p> <p>16 type.</p> <p>17 Do you see that?</p> <p>18 A. I do see that here.</p> <p>19 Q. Okay. It says, "A, the</p> <p>20 presence of fiber aspect ratios in the range</p> <p>21 of 20 to 1 or higher for fibers longer than</p> <p>22 5 microns."</p> <p>23 Do you see that?</p> <p>24 A. Yes.</p> <p>25 Be careful, you're diverting</p>	<p>1 A. So before I answer that</p> <p>2 question, I'd like to back up to your last</p> <p>3 question and point out that there's a note at</p> <p>4 the end of this section which says, "This is</p> <p>5 intended as guidance for analysts, and it is</p> <p>6 not intended to override the definition of</p> <p>7 asbestos as presented in 2.9."</p> <p>8 So let's make sure we make a</p> <p>9 note of the fact that these morphology</p> <p>10 comments here are intended as guidance and</p> <p>11 not as overriding other considerations</p> <p>12 elsewhere in the document.</p> <p>13 All right. Now --</p> <p>14 Q. And it also refers to national</p> <p>15 regulation. It's not intended to override</p> <p>16 any national regulation, correct?</p> <p>17 A. That's what it says.</p> <p>18 Now, if we can go back to your</p> <p>19 question.</p> <p>20 Q. So my question is: Other than</p> <p>21 the statistical test of aspect ratios on a</p> <p>22 population basis, is there any quantitative,</p> <p>23 objective way that you know of to identify</p> <p>24 the morphology of a bundle as being a bundle</p> <p>25 of asbestos fibers versus a cleavage</p>

80 (Pages 314 to 317)

Melinda Darby Dyar, Ph.D.

Page 318	Page 320
<p>1 fragment?</p> <p>2 MR. FROST: Objection to form.</p> <p>3 THE WITNESS: Let's see.</p> <p>4 "Other than."</p> <p>5 So we've established that</p> <p>6 statistical tests of particle</p> <p>7 dimensions on populations are the best</p> <p>8 and only way to determine whether</p> <p>9 something is asbestiform and</p> <p>10 non-asbestiform.</p> <p>11 From an individual particle and</p> <p>12 a two-dimensional image, it is</p> <p>13 impossible to make those kinds of</p> <p>14 judgments.</p> <p>15 QUESTIONS BY MR. FINCH:</p> <p>16 Q. Would you agree with me that</p> <p>17 Section 7.2.3.7.1 says, "In light microscope,</p> <p>18 the asbestiform habit is generally recognized</p> <p>19 by the following characteristics," and it</p> <p>20 lists characteristics that do not discuss the</p> <p>21 statistical testing of a population of -- on</p> <p>22 an aspect ratio basis?</p> <p>23 A. My interpretation of this</p> <p>24 document is verbatim what it says, which is</p> <p>25 this is intended for guidance. It's not</p>	<p>1 the amphibole is probably non-asbestiform,</p> <p>2 with a degree of certainty increasing with</p> <p>3 decreasing maximum aspect ratio. If any</p> <p>4 amphibole fibers longer than 5 microns with</p> <p>5 aspect ratios in the range of 20 to 1 or</p> <p>6 higher are observed, then it can be concluded</p> <p>7 that amphibole asbestos is probably present,</p> <p>8 with a degree of certainty increasing with</p> <p>9 increasing aspect ratio."</p> <p>10 Did I read that correctly?</p> <p>11 A. You read it correctly.</p> <p>12 Q. And it says, if any amphibole</p> <p>13 fibers longer than 5 microns with an aspect</p> <p>14 ratio in the range of 20 or {sic} 1 or higher</p> <p>15 are observed, then it can be concluded that</p> <p>16 amphibole asbestos is probably present.</p> <p>17 Right?</p> <p>18 A. That's what it says.</p> <p>19 Q. So that means -- "any" means</p> <p>20 more than 1, correct?</p> <p>21 If you've got any amphibole</p> <p>22 fibers longer than 5 microns with an aspect</p> <p>23 ratio in the range of 20 or 1 to higher, ISO</p> <p>24 22262-1, Section 7.2.3.7.1, says that it can</p> <p>25 be concluded that amphibole asbestos is</p>
Page 319	Page 321
<p>1 intended to be, as it says, a way to</p> <p>2 discriminate between non-asbestiform and</p> <p>3 asbestiform amphibole populations in a</p> <p>4 rigorous way.</p> <p>5 Q. Okay. On page 23, in the same</p> <p>6 section, in the text below number 5 --</p> <p>7 A. Uh-huh.</p> <p>8 Q. -- it has a discussion in the</p> <p>9 second paragraph that begins "In general."</p> <p>10 Do you see that?</p> <p>11 A. Yes.</p> <p>12 Q. Okay. ISO 22262-1 states, "In</p> <p>13 general, for this part of ISO 22262, the</p> <p>14 presence of either the asbestiform or the</p> <p>15 non-asbestiform analogs of tremolite and</p> <p>16 actinolite, anthophyllite or richterite,</p> <p>17 winchite, can usually be specified. If the</p> <p>18 majority of the amphibole fibers longer than</p> <p>19 5 microns have aspect ratios equal to or</p> <p>20 lower than 5 to 1, and if the fibers do not</p> <p>21 exhibit any of the characteristics in C" --</p> <p>22 Which is referring back to</p> <p>23 page 22, correct?</p> <p>24 A. Yes.</p> <p>25 Q. -- "it can be concluded that</p>	<p>1 probably present, with a degree of certainty</p> <p>2 increasing with increasing aspect ratio?</p> <p>3 A. Let us, again, point out that</p> <p>4 immediately following the paragraph you wrote</p> <p>5 {sic} it says, "This is intended for guidance</p> <p>6 for an analyst," first of all.</p> <p>7 And second of all, let's go</p> <p>8 back and look at the populations in this</p> <p>9 particular situation. And in fact, it says</p> <p>10 that the average aspect ratio of all</p> <p>11 particles looked at by Longo and Rigler is</p> <p>12 13.34.</p> <p>13 So under their own</p> <p>14 definition -- or under the definition in this</p> <p>15 document, none of the particles identified by</p> <p>16 Drs. Longo and Rigler would be considered to</p> <p>17 be asbestiform. So you're arguing my own</p> <p>18 point.</p> <p>19 Q. Average doesn't mean -- the</p> <p>20 average -- you said Longo and Rigler found</p> <p>21 that the average aspect ratio was 13 point</p> <p>22 something, correct?</p> <p>23 A. Correct.</p> <p>24 Q. Average is not the same as the</p> <p>25 longest, correct?</p>

81 (Pages 318 to 321)

Melinda Darby Dyar, Ph.D.

Page 322	Page 324
<p>1 A. That's correct. But it is also</p> <p>2 the case that population distribution of</p> <p>3 non-asbestiform and asbestiform amphiboles</p> <p>4 would all have some samples since it's an</p> <p>5 asymptotic distribution potentially in the 20</p> <p>6 to 1 range.</p> <p>7 Q. Does -- isn't it true that</p> <p>8 Dr. Longo and Dr. Rigler did find amphibole</p> <p>9 fibers that were longer than 5 microns which</p> <p>10 had an aspect ratio of 20 to 1 or higher?</p> <p>11 A. I don't know. Very few of</p> <p>12 them, based on the information in the plot</p> <p>13 and figure of 28 C, a very, very small</p> <p>14 percentage of the Longo and Rigler samples</p> <p>15 have aspect ratios that are greater than 20</p> <p>16 to 1.</p> <p>17 Q. Okay. And doesn't it say if</p> <p>18 any amphibole fibers longer -- any meaning</p> <p>19 any, not average -- any amphibole fibers</p> <p>20 longer than 5 microns with aspect ratios in</p> <p>21 the range of 20 to 1 or higher are observed,</p> <p>22 then it can be concluded that amphibole</p> <p>23 asbestos is probably present?</p> <p>24 That's what ISO 22262-1 says,</p> <p>25 does it not?</p>	<p>1 of particles was still 13, which is well</p> <p>2 below 20 to 1.</p> <p>3 Q. Where does it say that the</p> <p>4 average aspect -- in ISO 22262-1 does it say</p> <p>5 in Section C, Section 72371, that the average</p> <p>6 aspect ratio has to be in the range of 20 to</p> <p>7 1 or higher?</p> <p>8 A. It says, "This is intended as</p> <p>9 guidance for the analyst to discriminate</p> <p>10 between non-asbestiform and asbestiform</p> <p>11 amphibole populations."</p> <p>12 So to me it is implied that</p> <p>13 these measurements would be made on multiple</p> <p>14 samples in order to accumulate enough data to</p> <p>15 understand the population represented.</p> <p>16 Q. And in analyzing the aspect</p> <p>17 ratios, am I not correct that in</p> <p>18 Section 7.2.3.7.1 of ISO 22262-1 they are</p> <p>19 talking about the aspect ratios for fibers</p> <p>20 longer than 5 microns? Correct?</p> <p>21 A. It just gives a guidance that,</p> <p>22 yes, if any amphibole fibers longer than</p> <p>23 5 microns -- that's what it says there.</p> <p>24 Q. And if any amphibole fiber with</p> <p>25 longer than 5 microns has an aspect ratio of</p>
Page 323	Page 325
<p>1 A. That is what it says, but below</p> <p>2 that it also says "this is intended only as</p> <p>3 guidance."</p> <p>4 And then it mentions</p> <p>5 populations, which is, of course, the more</p> <p>6 appropriate analysis, which is what I've done</p> <p>7 in the report.</p> <p>8 Q. Okay. And in your report when</p> <p>9 you're analyzing the populations, am I</p> <p>10 correct that you say that -- you fault</p> <p>11 Dr. Longo and Rigler for only analyzing the</p> <p>12 average aspect ratio for particles longer</p> <p>13 than 5 microns, correct?</p> <p>14 MR. CHACHKES: Objection.</p> <p>15 THE WITNESS: Yes, that's what</p> <p>16 I say.</p> <p>17 QUESTIONS BY MR. FINCH:</p> <p>18 Q. All right. And --</p> <p>19 A. Well, in point of fact what I</p> <p>20 say is that they only counted particles with</p> <p>21 aspect ratios greater than 5 to 1, which</p> <p>22 improperly biases their results toward</p> <p>23 finding an asbestiform particle population,</p> <p>24 although it was unsuccessful. Because even</p> <p>25 with that limitation, their mean aspect ratio</p>	<p>1 20 to 1 or higher, then it could be concluded</p> <p>2 that amphibole asbestos is probably present.</p> <p>3 And this is in a guidance</p> <p>4 document for analysts to discriminate between</p> <p>5 non-asbestiform and asbestiform amphibole</p> <p>6 populations?</p> <p>7 A. I think we can agree to</p> <p>8 disagree here. The term "probably" is used</p> <p>9 in this sentence, and then it's followed by a</p> <p>10 note that says that this is intended as</p> <p>11 guidance to discriminate between populations.</p> <p>12 So I believe that the pop --</p> <p>13 the use of populations is the absolute</p> <p>14 paramount, most useful method for</p> <p>15 discriminating morphologies.</p> <p>16 And let's bring it back to the</p> <p>17 Longo and Rigler report, too. So in the</p> <p>18 Longo and Rigler report they use TEM to</p> <p>19 visually distinguish these things, so they</p> <p>20 are -- their conclusions are not using aspect</p> <p>21 ratios in any way.</p> <p>22 Q. Doesn't Dr. Longo have analysis</p> <p>23 of aspect ratio of the structures he analyzes</p> <p>24 that you recreate at --</p> <p>25 A. He presents that information in</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 326</p> <p>1 his tables, but I believe that in his</p> <p>2 deposition he indicated that the terminology</p> <p>3 that's associated with the images is made at</p> <p>4 the time of acquisition, before there's any</p> <p>5 analysis -- before any analysis has been</p> <p>6 undertaken.</p> <p>7 Q. Isn't it true -- you say in</p> <p>8 footnote 94, "Although the longer Rigler MDL</p> <p>9 reports utilize PLM for evaluating optical</p> <p>10 properties, the reports do not give aspect</p> <p>11 ratios for studied particles either in the</p> <p>12 photomicrographs themselves or in any of the</p> <p>13 tables."</p> <p>14 A. For the PLM data, I believe</p> <p>15 that is correct.</p> <p>16 Q. All right. We just looked at</p> <p>17 exhibit -- I think it's Exhibit 22, which was</p> <p>18 Section 13.</p> <p>19 A. It's in here somewhere. Here</p> <p>20 we go.</p> <p>21 Q. And am I correct that in</p> <p>22 multiple places in the PLM images in</p> <p>23 Exhibit 22 there are measurements of the</p> <p>24 length of the structure in microns, and in</p> <p>25 the tables there are -- there are -- there is</p>	<p style="text-align: right;">Page 328</p> <p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. An aspect ratio is simply</p> <p>3 dividing the length by the width, right?</p> <p>4 A. That's correct.</p> <p>5 But I would point out that many</p> <p>6 of the images like this one do not include</p> <p>7 measurements.</p> <p>8 Q. But the count sheets do that</p> <p>9 back up the images, correct?</p> <p>10 A. When they are provided.</p> <p>11 Q. Did --</p> <p>12 A. It's unclear to my -- I'd have</p> <p>13 to go back and look. It's unclear to me</p> <p>14 whether both -- whether all the PLM</p> <p>15 measurements, including those done by Lepoy</p> <p>16 {phonetic} and those done by Longo and</p> <p>17 Rigler, included such count sheets.</p> <p>18 Q. Okay. You say that --</p> <p>19 A. But in any case, it's</p> <p>20 irrelevant because the population mean of all</p> <p>21 of these particles is not high enough to be</p> <p>22 consistent with the presence of a population</p> <p>23 of asbestiform minerals.</p> <p>24 Q. All right. The population mean</p> <p>25 that Drs. Longo and Rigler calculated was an</p>
<p style="text-align: right;">Page 327</p> <p>1 data in the count sheets for each structure</p> <p>2 as to its length and width which would enable</p> <p>3 you to calculate an aspect ratio?</p> <p>4 A. What did I exactly say in my</p> <p>5 report?</p> <p>6 I was looking for tables that</p> <p>7 counted aspect ratios, and there is no aspect</p> <p>8 ratio in this particular document.</p> <p>9 Q. Right.</p> <p>10 But the data from which one</p> <p>11 could calculate aspect ratios is available in</p> <p>12 every count sheet, correct?</p> <p>13 A. But that's not what I said.</p> <p>14 What I said in my report was,</p> <p>15 the reports do not give aspect ratios for</p> <p>16 studied particles.</p> <p>17 Q. The reports give you all the</p> <p>18 data you need to calculate the aspect ratios</p> <p>19 for every single particle studied, correct?</p> <p>20 MR. CHACHKES: Objection.</p> <p>21 THE WITNESS: I would have to</p> <p>22 review the data again to make sure</p> <p>23 that those are all there. I don't</p> <p>24 recall.</p> <p>25</p>	<p style="text-align: right;">Page 329</p> <p>1 aspect ratio of 13.34, right?</p> <p>2 A. By my calculations, yes.</p> <p>3 Q. And what publication do you</p> <p>4 rely upon for your conclusion that it is a</p> <p>5 requirement under the international standards</p> <p>6 for analyzing asbestos that the aspect -- the</p> <p>7 average aspect ratio must be higher than 20</p> <p>8 to 1?</p> <p>9 MR. CHACHKES: Objection.</p> <p>10 THE WITNESS: I don't rely for</p> <p>11 my conclusion on the requirement that</p> <p>12 the aspect ratio be higher than 20 to</p> <p>13 1. I'm just pointing out, apropos of</p> <p>14 the discussion we just had about ISO</p> <p>15 22262-1, that it happens to mention</p> <p>16 aspect ratios of greater than 20 to 1.</p> <p>17 And I'm pointing out that as it</p> <p>18 happens, the aspect ratio of all the</p> <p>19 particles' population measured by</p> <p>20 Longo and Rigler is significantly</p> <p>21 lower than that. That's all I'm</p> <p>22 saying.</p> <p>23 (Dyar Exhibit 23 marked for</p> <p>24 identification.)</p> <p>25</p>

Melinda Darby Dyar, Ph.D.

Page 330	Page 332
<p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. All right. Let's mark this as</p> <p>3 Exhibit 23. This is Exhibit Number 23, I</p> <p>4 hope.</p> <p>5 Have you ever seen this</p> <p>6 document before?</p> <p>7 A. Nope.</p> <p>8 Q. Do you recognize Richard Lee as</p> <p>9 the president of the organization that Matt</p> <p>10 Sanchez works for?</p> <p>11 A. I assume so. I assume that's</p> <p>12 what RJ Lee stands for.</p> <p>13 Q. And Ann Wylie is the scientist</p> <p>14 we talked about before. You rely on</p> <p>15 Dr. Wylie's publications in part for your</p> <p>16 opinions in this case?</p> <p>17 A. Certainly I cited some of Ann's</p> <p>18 publications, yes.</p> <p>19 Q. This is a non-peer-reviewed</p> <p>20 publication that they put together describing</p> <p>21 what is asbestos.</p> <p>22 Do you see that?</p> <p>23 A. I can see that it's from a</p> <p>24 non-peer-reviewed source, yes.</p> <p>25 Q. All right. And on pages 6 and</p>	<p>1 both the mean aspect ratio and the outlier</p> <p>2 aspect ratios, correct?</p> <p>3 MR. CHACHKES: Objection.</p> <p>4 THE WITNESS: As an analyst,</p> <p>5 once you have the thing in the TEM,</p> <p>6 you'd like to collect as much data as</p> <p>7 possible. And, yes, a way as</p> <p>8 described in my report to determine</p> <p>9 the population of aspect ratios</p> <p>10 represented in your sample is to make</p> <p>11 multiple measurements, yes.</p> <p>12 QUESTIONS BY MR. FINCH:</p> <p>13 Q. I believe you said that you</p> <p>14 have met Ann Wylie but you couldn't pick her</p> <p>15 out of a crowd; is that correct?</p> <p>16 A. Correct.</p> <p>17 Q. Have you communicated with her</p> <p>18 in any way about your work in this case?</p> <p>19 A. No.</p> <p>20 Q. Have you submitted -- well, let</p> <p>21 me ask you this: Is your expert report in</p> <p>22 this case, Exhibit 2, been peer-reviewed?</p> <p>23 A. No.</p> <p>24 Q. Do you intend to submit it to</p> <p>25 any peer-reviewed journal?</p>
Page 331	Page 333
<p>1 7 --</p> <p>2 Does your copy have pages at</p> <p>3 the bottom?</p> <p>4 A. Yes, it does.</p> <p>5 Q. -- they have pictorial images</p> <p>6 of asbestos, asbestiform and non-asbestiform</p> <p>7 materials, correct?</p> <p>8 A. Yes.</p> <p>9 Q. And have you analyzed each of</p> <p>10 the structures identified by Dr. Longo's</p> <p>11 analysts and pictographs taken by Dr. Longo's</p> <p>12 analysts to determine whether or not they</p> <p>13 look more like the middle box under</p> <p>14 asbestiform than any of the materials -- any</p> <p>15 of the pictures of non-asbestiform on page 7?</p> <p>16 A. So the point is that it's very</p> <p>17 difficult to distinguish images on the basis</p> <p>18 of one TEM image which is only</p> <p>19 two-dimensional. You really need multiple</p> <p>20 measurements of the dimensions of a particle,</p> <p>21 on multiple particles, in order to make an</p> <p>22 assertive and a definitive decision.</p> <p>23 Q. And one way to do that is to</p> <p>24 analyze the aspect ratio of particles that</p> <p>25 are 5 microns long or longer to determine</p>	<p>1 A. It would not be appropriate.</p> <p>2 Q. Why not?</p> <p>3 A. Because it's simply an analysis</p> <p>4 of reports. It's nothing worthy of a</p> <p>5 peer-review journal. It's not -- it's not</p> <p>6 appropriate.</p> <p>7 Peer-reviewed journals are for</p> <p>8 fundamental research, which this is merely a</p> <p>9 report that critiques something else. Just</p> <p>10 as I would not ever submit my review of a</p> <p>11 paper as a peer-review article.</p> <p>12 MR. FINCH: Can I have the next</p> <p>13 document?</p> <p>14 (Dyar Exhibit 24 marked for</p> <p>15 identification.)</p> <p>16 QUESTIONS BY MR. FINCH:</p> <p>17 Q. Let's mark this as 24.</p> <p>18 Do you rely on US Geological</p> <p>19 Survey's Mineral Commodity profiles for</p> <p>20 anything, any aspect of your work?</p> <p>21 A. No.</p> <p>22 Q. Do you agree that the US</p> <p>23 Geological Survey is a reputable source if</p> <p>24 one is looking to identify what the US</p> <p>25 Geological Service considers asbestos to be?</p>

Melinda Darby Dyar, Ph.D.

Page 334	Page 336
<p>1 MR. CHACHKES: Objection.</p> <p>2 THE WITNESS: I haven't</p> <p>3 researched that, so I don't actually</p> <p>4 have a good answer for that.</p> <p>5 QUESTIONS BY MR. FINCH:</p> <p>6 Q. You cited to a publication by</p> <p>7 Wylie and Virta in your expert witness</p> <p>8 report, correct?</p> <p>9 A. That's correct.</p> <p>10 Q. And were you aware that's the</p> <p>11 same Virta who wrote the USGS Mineral</p> <p>12 Commodity profile "Asbestos" in 2005, by</p> <p>13 Robert L. Virta?</p> <p>14 A. Apparently that's the case.</p> <p>15 Q. And do you agree with me that</p> <p>16 the US Geological Survey Mineral Commodity</p> <p>17 profile for asbestos is the United States</p> <p>18 government's definition of what constitutes</p> <p>19 asbestos from the perspective of the geology</p> <p>20 scientists that work for the USGS?</p> <p>21 MR. CHACHKES: Objection.</p> <p>22 THE WITNESS: You know, you've</p> <p>23 just given me a 56-page document, and</p> <p>24 we have a very short time left. I'd</p> <p>25 be happy to use it to evaluate this</p>	<p>1 because I didn't research that particular</p> <p>2 area.</p> <p>3 Q. Would you agree with me that</p> <p>4 ISO 22262-1, ISO 22262-2 and the Yamate</p> <p>5 document on which you rely don't have any</p> <p>6 techniques or methodologies for measuring</p> <p>7 tensile strength in order to characterize</p> <p>8 something as asbestos or not?</p> <p>9 A. All of those documents define</p> <p>10 fibers as having high tensile strength, and</p> <p>11 they give guidelines for different analytical</p> <p>12 tools that can be used to characterize</p> <p>13 different characteristics of particles, but</p> <p>14 they don't give -- they're not intended to be</p> <p>15 exclusive.</p> <p>16 So, no, I'm not aware that</p> <p>17 those documents include information on how to</p> <p>18 do that. Perhaps there's an ISO 66, whatever</p> <p>19 it is, 4, that will pursue that.</p> <p>20 Q. Turn to Table 11 of exhibit --</p> <p>21 whatever this next one is.</p> <p>22 A. In what?</p> <p>23 Q. 24, the Virta US Geological</p> <p>24 Survey.</p> <p>25 A. I'm sorry, page what?</p>
Page 335	Page 337
<p>1 document, but I can't answer your</p> <p>2 question without actually reading this</p> <p>3 document.</p> <p>4 QUESTIONS BY MR. FINCH:</p> <p>5 Q. Does tensile strength have</p> <p>6 anything to do with determining whether what</p> <p>7 you see under a microscope is a cleavement</p> <p>8 fragment -- a cleavage fragment or an</p> <p>9 asbestos bundle?</p> <p>10 A. So I believe we established</p> <p>11 earlier that the definition of a fiber</p> <p>12 includes the qualifier that it has to be</p> <p>13 flexible and have high tensile strength, and</p> <p>14 that's the definition which is ubiquitous</p> <p>15 across many different sources.</p> <p>16 Q. Is there any peer-reviewed</p> <p>17 publication that you know of that tells you</p> <p>18 how to measure tensile strength in an</p> <p>19 asbestos fiber or bundle which is 20 microns</p> <p>20 long or less?</p> <p>21 A. Well, let's recall that my role</p> <p>22 here is to assess the methodology used by</p> <p>23 Drs. Longo and Rigler, not the methodology</p> <p>24 that they didn't use.</p> <p>25 So I have no opinion on that</p>	<p>1 Q. Page 14, Table 11.</p> <p>2 A. Uh-huh.</p> <p>3 Q. Properties of asbestos fibers.</p> <p>4 Do you see that?</p> <p>5 A. I see.</p> <p>6 Q. All right. There is -- it</p> <p>7 lists essential composition, crystal system.</p> <p>8 Do you see that?</p> <p>9 A. Uh-huh.</p> <p>10 Q. Is that a yes?</p> <p>11 A. I do see that.</p> <p>12 Q. Okay.</p> <p>13 A. The list.</p> <p>14 Q. And then there's a -- there is</p> <p>15 a discussion -- there is a description of</p> <p>16 flexibility at the bottom, right?</p> <p>17 A. Yes.</p> <p>18 Q. There's also a discussion or</p> <p>19 description of tensile strength about</p> <p>20 two-thirds of the way down the chart, right?</p> <p>21 A. There are measurements -- or</p> <p>22 there are numbers reported there, yes.</p> <p>23 Q. All right. Would you agree</p> <p>24 with me that tremolite asbestos is described</p> <p>25 as having poor flexibility as compared to</p>

Melinda Darby Dyar, Ph.D.

Page 338	Page 340
<p>1 crocidolite, chrysotile or amosite?</p> <p>2 A. Let's see here. I have no idea</p> <p>3 without reading the paper what this means.</p> <p>4 You're taking this table and asking me to</p> <p>5 interpret it completely out of context.</p> <p>6 Just because something has poor</p> <p>7 flexibility doesn't mean that it's not</p> <p>8 flexible, and the definition is that it has</p> <p>9 to be flexible.</p> <p>10 In fact, the numbers indicated</p> <p>11 here for tensile strength indicate that these</p> <p>12 things are flexible.</p> <p>13 Q. Well, isn't it true that the</p> <p>14 tensile strength is measured in thousand</p> <p>15 pascals?</p> <p>16 A. It is reported in thousand</p> <p>17 pascals, according to this chart.</p> <p>18 Q. Right.</p> <p>19 And, for example, tremolite and</p> <p>20 anthophyllite -- let's start with</p> <p>21 anthophyllite. That's 27,000 pascals or</p> <p>22 less, right?</p> <p>23 A. That's what it says here.</p> <p>24 Q. And that is -- and then</p> <p>25 actinolite is 6,000 pascals or less, correct?</p>	<p>1 and flexibility was not done by Drs. Longo</p> <p>2 and Rigler, and this document makes it clear</p> <p>3 that it is possible.</p> <p>4 So another method --</p> <p>5 methodological flaw of this Longo and Rigler</p> <p>6 report, which you've nicely given me the data</p> <p>7 for, is that in fact it is possible to</p> <p>8 measure tensile strength for these particles,</p> <p>9 and Drs. Longo and Rigler did not do so.</p> <p>10 Q. Do you know if the tensile</p> <p>11 strength measured in this document is from</p> <p>12 microscopic particles or particles that are</p> <p>13 large enough to see by the naked eye?</p> <p>14 A. Again, I've only looked at this</p> <p>15 document for a total of three minutes. I</p> <p>16 have not had adequate time to either read</p> <p>17 what the explanation says or to go back and</p> <p>18 look at the references to determine the</p> <p>19 particle sizes, so I can't answer that</p> <p>20 question.</p> <p>21 Q. Can you point to a source that</p> <p>22 you would consider reliable for what is the</p> <p>23 minimum threshold for tensile strength to</p> <p>24 characterize a given structure as asbestos or</p> <p>25 not?</p>
Page 339	Page 341
<p>1 MR. CHACHKES: Objection.</p> <p>2 THE WITNESS: That's what it</p> <p>3 says here.</p> <p>4 QUESTIONS BY MR. FINCH:</p> <p>5 Q. And tremolite is 6800 to</p> <p>6 55,000, correct?</p> <p>7 A. That's what it says here.</p> <p>8 Q. Would you agree with me that</p> <p>9 the low range for tensile strength for</p> <p>10 tremolite asbestos is two orders of magnitude</p> <p>11 less than the tensile strength for the low</p> <p>12 end of crocidolite?</p> <p>13 A. According to these numbers,</p> <p>14 yes, but I have -- would have to have more</p> <p>15 time to review this document to determine</p> <p>16 where those numbers came from and how</p> <p>17 reliable they are.</p> <p>18 It looks like some of those</p> <p>19 come from studies that were done in the</p> <p>20 1950s, and I would question the reliability</p> <p>21 of those.</p> <p>22 So that would be my response to</p> <p>23 this.</p> <p>24 And I would also go back and</p> <p>25 say that quantification of tensile strength</p>	<p>1 A. I believe I've already stated</p> <p>2 in this deposition that I am not familiar</p> <p>3 with the analytical techniques used to</p> <p>4 measure tensile strength or flexibility</p> <p>5 because I was -- they were not among the</p> <p>6 methods used by Drs. Longo and Rigler, and my</p> <p>7 job here was to assess the methodology.</p> <p>8 So this whole issue is not</p> <p>9 relevant to that particular documents --</p> <p>10 those particular documents except as to say</p> <p>11 they didn't measure this. So...</p> <p>12 Q. Do you have any understanding</p> <p>13 one way or another as to whether OSHA, the</p> <p>14 Occupational Safety and Health</p> <p>15 Administration, and MSHA, the Mine Safety and</p> <p>16 Health Administration, regulate fibrous talc</p> <p>17 as asbestos?</p> <p>18 MR. FROST: Objection.</p> <p>19 MR. CHACHKES: Objection.</p> <p>20 THE WITNESS: I know nothing</p> <p>21 about that.</p> <p>22 QUESTIONS BY MR. FINCH:</p> <p>23 Q. Do you know whether or not IARC</p> <p>24 considers fibrous talc to be an asbestiform</p> <p>25 mineral?</p>

Melinda Darby Dyar, Ph.D.

Page 342	Page 344
<p>1 MR. FROST: Objection. 2 MR. CHACHKES: Objection. 3 THE WITNESS: I don't recall 4 seeing that in the IARC documents I 5 read, but my focus in these documents 6 was to assess methodology. It 7 wasn't -- it wasn't to consider talc 8 itself. 9 QUESTIONS BY MR. FINCH: 10 Q. I notice you don't have any 11 criticism of Dr. Longo and Rigler's 12 conclusions of the particles they find that 13 are fibrous talc; is that correct? 14 A. I didn't consider them. I 15 considered only the question of methodology 16 as it relates to the presence or absence of 17 asbestiform minerals. 18 Q. So the methodology they 19 followed to determine the presence or absence 20 of fibrous talc was not a subject of your 21 work or analysis in this report in this case, 22 correct? 23 MR. CHACHKES: Objection. 24 THE WITNESS: Talc is not a 25 regulated asbestos mineral and,</p>	<p>1 USGS report, we saw that those were the units 2 that were used, yes. 3 Q. Well, the units that were used 4 were pascal joules in the USGS report. 5 What I also ask you: Isn't it 6 true that pounds per square inch can be a 7 measurement of tensile strength if you're 8 stretching a material as opposed to squishing 9 a material? 10 MR. FROST: Objection. 11 THE WITNESS: Not as far as I 12 know. 13 QUESTIONS BY MR. FINCH: 14 Q. This is the document from a 15 textbook. This is the article by Badollet 16 cited by the Virta article, "Asbestos: A 17 Mineral of Unparalleled Properties," that 18 describes the physical properties of 19 asbestos. 20 Do you see that? 21 A. Yes. 22 Q. And it's got the tensile 23 strength of the various -- of the six 24 different regulated varieties of asbestos 25 measured in pounds per square inch.</p>
Page 343	Page 345
<p>1 therefore, I did not consider the 2 information in the report relating to 3 it. 4 MR. FINCH: Time. Stop. Off 5 the record. 6 VIDEOGRAPHER: Off the record? 7 MR. FINCH: Off the record. I 8 want to go off the record. 9 VIDEOGRAPHER: The time is 10 6:13 p.m. Off the record. 11 (Off the record at 6:14 p.m.) 12 VIDEOGRAPHER: The time is 13 6:22 p.m. Back on record. 14 (Dyar Exhibit 25 marked for 15 identification.) 16 QUESTIONS BY MR. FINCH: 17 Q. Good evening, Professor Darby 18 Dyar. We're back on the record after a short 19 break. 20 I'm going to put what's been 21 marked as Exhibit 25 in front of you. 22 I believe you agreed with me 23 earlier today that tensile strength can be 24 measured in pounds per square inch? 25 A. So when we were looking at the</p>	<p>1 Do you see that on page 237 at 2 the -- at the second -- 3 A. Well, the first thing I see is 4 that this paper was written 67 years ago, 5 which would make me doubt the accuracy of 6 these measurements, with all due respect to 7 this individual. 8 Q. Would you -- 9 A. But I'll take a look at 10 page 237. 11 Q. Yeah. 12 A. That's -- 13 Q. Tensile strength. They have a 14 measurement in pounds per square inch of the 15 tensile strength of chrysotile, amosite, 16 anthophyllite, crocidolite, tremolite and 17 actinolite. 18 A. That's a very weird 19 measurement, but that's what they give here, 20 yes. 21 Q. Okay. And then on Table 7 at 22 page 241, am I correct that they compare the 23 tensile strength of various varieties of 24 asbestos to other types of material? 25 A. You know, this is a pretty long</p>

Melinda Darby Dyar, Ph.D.

Page 346	Page 348
<p>1 document, and I've only had it in my hand for</p> <p>2 two minutes. If you give me a while, I could</p> <p>3 read this.</p> <p>4 There is a table that says</p> <p>5 comparison of tensile strengths, but --</p> <p>6 Q. Comparison of tensile strengths</p> <p>7 of various materials. Table 7, type of</p> <p>8 material for cotton fiber, the tensile</p> <p>9 strength is 73,000 to 89,000 pounds per</p> <p>10 square inch.</p> <p>11 Do you see that?</p> <p>12 A. I see this table, but again, I</p> <p>13 would doubt these measurements given that</p> <p>14 they are 67 years old.</p> <p>15 Q. Okay. Do you agree with me</p> <p>16 that tremolite asbestos has a substantially</p> <p>17 lower tensile strength than wrought iron,</p> <p>18 ingot iron, carbon steel, piano steel wire,</p> <p>19 cotton fiber?</p> <p>20 A. I agree that that's what this</p> <p>21 67-year-old document says, but again, I would</p> <p>22 question this source and ask for more modern</p> <p>23 measurements.</p> <p>24 Q. Do you have any more modern</p> <p>25 measurements of the relationship between the</p>	<p>1 label says in the paper, yes, but I --</p> <p>2 again, I have called into question a</p> <p>3 document that's 67 years old. It's</p> <p>4 probably more. It was probably</p> <p>5 written 68 years ago.</p> <p>6 QUESTIONS BY MR. FINCH:</p> <p>7 Q. 67 years ago the United States</p> <p>8 was able to develop a hydrogen bomb, correct?</p> <p>9 MR. FROST: Objection.</p> <p>10 THE WITNESS: That's correct.</p> <p>11 QUESTIONS BY MR. FINCH:</p> <p>12 Q. Just because technology is old</p> <p>13 doesn't mean it's -- just because science is</p> <p>14 old doesn't mean it's outmoded, correct?</p> <p>15 MR. FROST: Objection.</p> <p>16 THE WITNESS: I don't -- I'm</p> <p>17 not going to render an opinion on</p> <p>18 that.</p> <p>19 QUESTIONS BY MR. FINCH:</p> <p>20 Q. Well, you study rocks found on</p> <p>21 the moon and Mars, right?</p> <p>22 A. As part of my research, yes.</p> <p>23 Q. When is the last time anybody</p> <p>24 put a man on the surface of the moon?</p> <p>25 A. 50 years ago.</p>
Page 347	Page 349
<p>1 tensile strength of tremolite asbestos as</p> <p>2 compared to something like wrought iron?</p> <p>3 A. Again, let's return to the</p> <p>4 point that my goal was to review the</p> <p>5 methodology in this report. And since</p> <p>6 Drs. Longo and Rigler did not consider the</p> <p>7 topic of flexibility or tensile strength in</p> <p>8 their report, then I've not studied this and,</p> <p>9 therefore, cannot render an opinion on this.</p> <p>10 Q. On page 243, Figure 35, what</p> <p>11 does that say that is?</p> <p>12 A. Electron micrograph, amosite</p> <p>13 asbestos times 15200.</p> <p>14 Q. And can you put this on the</p> <p>15 videotape? Just --</p> <p>16 VIDEOGRAPHER: So if you put it</p> <p>17 on the Elmo, it's going to record it.</p> <p>18 MR. FINCH: Oh, it's getting</p> <p>19 recorded. Okay. I thought that was</p> <p>20 the case, but...</p> <p>21 QUESTIONS BY MR. FINCH:</p> <p>22 Q. So the authors of this are</p> <p>23 calling this amosite asbestos?</p> <p>24 MR. FROST: Objection.</p> <p>25 THE WITNESS: That's what the</p>	<p>1 Q. Over 50 years ago?</p> <p>2 A. Uh-huh.</p> <p>3 Q. You -- am I correct that your</p> <p>4 annual salary as a professor is approximately</p> <p>5 \$125,000 a year?</p> <p>6 A. Salaries at Mount Holyoke</p> <p>7 College are not publicly available, so I</p> <p>8 don't know where you got that information,</p> <p>9 and I'm not comfortable indicating my salary.</p> <p>10 Q. Okay. How does your</p> <p>11 compensation that you've been paid by Johnson</p> <p>12 & Johnson for this report compare to your</p> <p>13 annual salary from your full-time job as a</p> <p>14 professor?</p> <p>15 A. At the present time, it's hard</p> <p>16 to say. I have not been doing this very</p> <p>17 long, so it's hard to say.</p> <p>18 And I would also note that I am</p> <p>19 also employed as a senior scientist at the</p> <p>20 Planetary Science Institute in Tucson,</p> <p>21 Arizona, and I receive a considerable</p> <p>22 proportion of my salary from that</p> <p>23 organization as well.</p> <p>24 Q. How does the -- in percentage</p> <p>25 terms, how does the compensation that you've</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 350</p> <p>1 been paid by Johnson & Johnson in the past 2 four months compare to your total 3 compensation from other sources on an annual 4 basis? 5 MR. CHACHKES: Objection. 6 THE WITNESS: It's certainly 7 less than my total compensation from 8 other sources. 9 QUESTIONS BY MR. FINCH: 10 Q. Is it 50 percent of your total 11 compensation from other sources? 12 A. I actually don't know. 13 My income varies with the 14 number of research grants I have and the 15 number of hours I charge to them, and so it's 16 hard to give a precise answer to that 17 question. 18 Q. Have you ever been given a 19 research grant by the United States 20 government to study whether or not there is 21 asbestos in any material? 22 A. No. Not that I recall. 23 (Dyar Exhibit 26 marked for 24 identification.) 25</p>	<p style="text-align: right;">Page 352</p> <p>1 QUESTIONS BY MR. FINCH: 2 Q. Under Section 13.0, TEM 3 analysis. 4 Do you see that? 5 A. I see that section, yes. 6 Q. Do you agree with Johnson & 7 Johnson's definition of fiber? 8 MR. CHACHKES: Objection. 9 THE WITNESS: I have defined 10 fiber in my report with a very 11 specific definition which has lots of 12 agreement in -- both in my literature 13 and in government documents. 14 QUESTIONS BY MR. FINCH: 15 Q. My question was: Do you agree 16 with Johnson & Johnson's definition of 17 asbestos fiber as found in Exhibit Number 27 18 {sic}? 19 MR. CHACHKES: Objection. 20 QUESTIONS BY MR. FINCH: 21 Q. 26. Or 26, I think. 22 A. So this is not the same 23 definition that I use, but on the other hand, 24 I have not had time to read this document. I 25 don't know what the context of this document</p>
<p style="text-align: right;">Page 351</p> <p>1 QUESTIONS BY MR. FINCH: 2 Q. Last exhibit, I believe, 3 Exhibit 26. 4 Doctor, Professor Darby Dyar, 5 Exhibit 26 is Johnson & Johnson Consumer 6 Companies Worldwide Specification describing 7 the methodology for the analysis of powdered 8 talc for asbestiform minerals by transmission 9 electron microscopy. 10 Have you ever seen this 11 document before? 12 A. No, sir. 13 Q. Under TEM analysis, you agree 14 with me that what they're talking about here 15 is analyzing talc for asbestiform minerals, 16 right, by TEM? 17 MR. CHACHKES: Objection. 18 THE WITNESS: In the 30 seconds 19 since I was handed this document, I 20 have hardly had time to even read the 21 title. But the title says, "Analysis 22 of Powdered Talc for Asbestiform 23 Minerals by Transmission Electron 24 Microscopy." 25</p>	<p style="text-align: right;">Page 353</p> <p>1 is. 2 I know nothing about this 3 document and would certainly need more time 4 than the remaining ten minutes to render an 5 opinion on this particular document. 6 Q. Okay. Suffice it to say you 7 have not compared the methodology followed by 8 Drs. Longo and Rigler to determine whether or 9 not there is asbestiform minerals in talc 10 with the procedure set forth in Johnson & 11 Johnson's TEM 7024 standard? 12 MR. CHACHKES: Objection. 13 THE WITNESS: I believe that we 14 have established that I have no 15 information and have not reviewed 16 documents relating to anything having 17 to do with Johnson & Johnson testing 18 procedures because that was not my 19 mandate. 20 My mandate was to evaluate the 21 methodology used by Drs. Longo and 22 Rigler. 23 QUESTIONS BY MR. FINCH: 24 Q. Did you bring any books or 25 materials with you today?</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 354</p> <p>1 A. Me personally, no.</p> <p>2 Q. Did the lawyer for Johnson &</p> <p>3 Johnson bring books or materials that you</p> <p>4 have relied upon as part of your work in this</p> <p>5 case that are -- some of which might be</p> <p>6 sitting on the floor behind you today?</p> <p>7 A. I know that he brought copies</p> <p>8 of my two books.</p> <p>9 Q. Okay. Can we just get the</p> <p>10 two -- your two books, just so I can see --</p> <p>11 have a picture of them on the record?</p> <p>12 MR. CHACHKES: Technically</p> <p>13 they're mine, I purchased them, but I</p> <p>14 can hand them out. Just a second.</p> <p>15 MR. FINCH: It's an interesting</p> <p>16 copyright law question as to who has</p> <p>17 the ultimate ownership --</p> <p>18 THE WITNESS: Yeah, you can buy</p> <p>19 your own so I can get the royalties.</p> <p>20 MR. CHACHKES: Yeah, this is --</p> <p>21 just for the record, this is -- I</p> <p>22 purchased this off of Amazon used, so</p> <p>23 it's -- it might be marked. I don't</p> <p>24 know.</p> <p>25</p>	<p style="text-align: right;">Page 356</p> <p>1 A. I don't actually rely on it. I</p> <p>2 cite it because I happen to be familiar with</p> <p>3 it. But the statistical tests in the report</p> <p>4 are commonplace and can be found in any</p> <p>5 introductory statistics textbook.</p> <p>6 Q. Did you bring anything else</p> <p>7 with you to the deposition today?</p> <p>8 A. No.</p> <p>9 Q. Anything else related -- I</p> <p>10 mean, obviously you brought yourself. I</p> <p>11 assume you brought a cell phone or something.</p> <p>12 But did you bring anything that</p> <p>13 you reviewed or relied upon as part of your</p> <p>14 work in this case to the deposition today?</p> <p>15 A. Other than the documents that I</p> <p>16 already referred to?</p> <p>17 Q. Yes.</p> <p>18 A. No.</p> <p>19 Q. You're almost done.</p> <p>20 The question pending was: Did</p> <p>21 you bring anything that you reviewed or</p> <p>22 relied upon as part of your work in this case</p> <p>23 to the deposition today.</p> <p>24 And you asked me, "Other than</p> <p>25 the documents I already referred to?" and my</p>
<p style="text-align: right;">Page 355</p> <p>1 QUESTIONS BY MR. FINCH:</p> <p>2 Q. Okay. Mineralogy and Optical</p> <p>3 Mineralogy. This is the book that you wrote</p> <p>4 with Dr. Gunther in 2008 that I showed you an</p> <p>5 excerpt of.</p> <p>6 VIDEOGRAPHER: You want to put</p> <p>7 it on the Elmo?</p> <p>8 MR. FINCH: Sure.</p> <p>9 THE WITNESS: Correct. It</p> <p>10 actually took us a decade to write</p> <p>11 this book, but it was published in</p> <p>12 2008.</p> <p>13 QUESTIONS BY MR. FINCH:</p> <p>14 Q. Okay. And what's the other</p> <p>15 book that you're an author of that you</p> <p>16 brought with you?</p> <p>17 MR. CHACHKES: Counsel brought.</p> <p>18 THE WITNESS: Geostatistics</p> <p>19 Explained, which is listed on my CV</p> <p>20 and referenced in the report.</p> <p>21 QUESTIONS BY MR. FINCH:</p> <p>22 Q. This is the -- one of the</p> <p>23 references that you rely upon for your</p> <p>24 statistical analysis set forth in the</p> <p>25 discussion of the population, correct?</p>	<p style="text-align: right;">Page 357</p> <p>1 qualification was "yes."</p> <p>2 Other than the documents that</p> <p>3 you've already referred to, did you bring</p> <p>4 anything else with you today?</p> <p>5 A. No.</p> <p>6 Q. All right. Are there any</p> <p>7 materials you rely on that are not either</p> <p>8 cited in your expert report or included in</p> <p>9 your reliance list that is attached to the</p> <p>10 back of your expert witness report?</p> <p>11 A. No.</p> <p>12 MR. FINCH: All right. That's</p> <p>13 all the questions I have at this time.</p> <p>14 MR. CHACHKES: I have a few</p> <p>15 questions. We don't have to take a</p> <p>16 break.</p> <p>17 CROSS-EXAMINATION</p> <p>18 QUESTIONS BY MR. CHACHKES:</p> <p>19 Q. Mr. Finch keeps referring to</p> <p>20 you as Ms. Darby Dyar.</p> <p>21 Do you have a graduate degree?</p> <p>22 A. I do. I have a graduate degree</p> <p>23 from MIT. And my last name is Dyar. Darby</p> <p>24 is my middle name.</p> <p>25 Q. Professor Dyar, why are you</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 358</p> <p>1 qualified to critique the Longo and Rigler 2 expert report? 3 A. So my qualifications for 4 reviewing this report are outlined in this 5 particular -- in my report, but among them I 6 have a Ph.D. from MIT. I spent a year as a 7 post doc at Cal Tech. I have been in 8 academia for nearly 40 years and have taught 9 mineralogy at least 20 times. 10 I've written more than 250 11 papers that were published in peer-reviewed 12 scientific literature. I've reviewed 13 hundreds of scientific documents in keeping 14 with the standards of my profession. And 15 I've worked on dozens of papers involving 16 amphibole mineralogy and serpentine 17 mineralogy. 18 Q. And have you received any 19 awards in the field of geology and 20 mineralogy? 21 A. I have. I've been honored to 22 become a fellow of the Mineralogical Society 23 of America, the Geochemical Society, and the 24 Geological Society of America. 25 I have also received national</p>	<p style="text-align: right;">Page 360</p> <p>1 research, it is necessary to use a TEM to 2 make visual examination of the interactions 3 between the microbes and the minerals. 4 So I'm intimately familiar with 5 these analyses myself and have supervised 6 many undergraduate and graduates' theses that 7 use TEM. 8 Q. And could you talk about your 9 experience with analyzing minerals using 10 SAED? 11 A. So in most cases when we 12 analyze something, when we take an image of 13 something with a TEM, we almost always do 14 SAED if it's possible to get a good pattern. 15 And so SAED patterns also 16 figure in my biomineralization research 17 prominently as well as in my teaching. I 18 should say that TEM and X-ray diffraction in 19 various forms are part of a typical topics 20 covered in a mineralogy course, and certainly 21 I would have covered them in my 20 mineralogy 22 courses. 23 Q. And can you talk about your 24 experience with analyzing minerals using EDS? 25 A. So EDS is the poor stepsister</p>
<p style="text-align: right;">Page 359</p> <p>1 and international awards in recognition of my 2 research excellence, including the Shoemaker 3 award from NASA, the Gilbert award from the 4 geological society, the Holly medal from the 5 Mineralogical Society of Canada, and the 6 Helmholtz award from the German space agency, 7 among others. 8 Q. Can you talk about your 9 experience with analyzing minerals with PLM? 10 A. So I first started using PLM as 11 an undergraduate in 1978, which is 41 years 12 ago, and I've used PLM every year since then. 13 I've taught courses in the use of a 14 polarizing light microscope. 15 It's a routine tool used by me 16 whenever I look at a rock for the first time. 17 I drag out the PLM and take a look at the 18 sample. 19 Q. Can you talk to -- about your 20 experience with analyzing minerals using 21 visual inspection with a TEM? 22 A. So, much of my research in the 23 past two decades has involved the field of 24 biomineralization, which is the interaction 25 of microbes in minerals. And in that</p>	<p style="text-align: right;">Page 361</p> <p>1 of the more accurate gold standard for 2 mineral analysis, which is electron probe 3 microanalysis. The two techniques use 4 exactly the same fundamental underlying 5 phenomena, they just have different 6 detectors, which is why EDS is not very 7 sensitive. Electron probe microanalysis is 8 extremely sensitive. 9 So, in fact, when I was a 10 graduate student, I was involved in a lot of 11 analytical technique development for 12 electron-based measurements of chemistry, and 13 these have evolved into these two different 14 tools. 15 So I was involved not just at 16 the ground floor of these methods, but there 17 are now things that I use routinely in my 18 research, in particular electron probe 19 microanalysis, because it is much more 20 accurate than EDS. 21 Q. And to what degree do you 22 routinely use these tools and techniques that 23 have been mentioned with reference to your 24 published papers? 25 A. So I strive to have 100 percent</p>

Melinda Darby Dyar, Ph.D.

Page 362	Page 364
<p>1 of the research I do culminate in the</p> <p>2 publication of a paper in a peer-reviewed</p> <p>3 journal. So all of these techniques are used</p> <p>4 prominently in my 250 and counting</p> <p>5 scientific, peer-reviewed papers.</p> <p>6 Q. Tell us some of the</p> <p>7 qualifications you have to critique</p> <p>8 methodologies for detecting asbestos, in</p> <p>9 particular.</p> <p>10 A. So there's nothing special</p> <p>11 about asbestos. It's a mineral. Amphibole</p> <p>12 is amphibole, and the distinction between the</p> <p>13 many different varieties and species in the</p> <p>14 amphibole group are very minor. So there's</p> <p>15 nothing particularly special about analyzing</p> <p>16 these materials. They're just minerals.</p> <p>17 Q. Do you have experience</p> <p>18 analyzing amphiboles?</p> <p>19 A. I think I've written at least</p> <p>20 20 or 30 papers about amphiboles using many,</p> <p>21 many different analytical techniques.</p> <p>22 Q. What, if anything, is there</p> <p>23 about asbestiform amphiboles that make them</p> <p>24 more or less of a challenge in terms of</p> <p>25 microscopy techniques that we've been talking</p>	<p>1 Q. Professor Dyar, of your 250 --</p> <p>2 you would agree with me 250-plus</p> <p>3 peer-reviewed papers, right?</p> <p>4 A. Correct.</p> <p>5 Q. Not a one of them are addressed</p> <p>6 to the subject of how to identify asbestos in</p> <p>7 talcum powder, correct?</p> <p>8 A. Correct.</p> <p>9 Q. Not a one of them is on the</p> <p>10 subject of how to identify asbestos in bulk</p> <p>11 materials, correct?</p> <p>12 A. Literally that is correct, but</p> <p>13 let's remember that I use the techniques that</p> <p>14 are used to identify asbestos in talc</p> <p>15 routinely, and those are figured -- are</p> <p>16 featured prominently in many of my papers.</p> <p>17 Q. You've never published a</p> <p>18 peer-reviewed paper where the subject of</p> <p>19 paper is how to identify asbestos in any</p> <p>20 substance, correct?</p> <p>21 A. Correct.</p> <p>22 Q. How much time do you spend in a</p> <p>23 laboratory on an annual basis analyzing</p> <p>24 materials to determine if they do or do not</p> <p>25 contain asbestiform asbestos minerals?</p>
Page 363	Page 365
<p>1 about today?</p> <p>2 A. Nothing in particular. The</p> <p>3 only challenge would be that sometimes the</p> <p>4 particle sizes are too small to be resolved</p> <p>5 with a polarizing light microscope, and you</p> <p>6 might need to use other techniques in those</p> <p>7 situations.</p> <p>8 MR. CHACHKES: No further</p> <p>9 questions.</p> <p>10 REDIRECT EXAMINATION</p> <p>11 QUESTIONS BY MR. FINCH:</p> <p>12 Q. 251 peer-reviewed papers; is</p> <p>13 that what you said, Doctor?</p> <p>14 A. You know, that number changes</p> <p>15 almost daily. I don't actually know what it</p> <p>16 is right now.</p> <p>17 Q. All right. Ballpark 300, plus</p> <p>18 or minus?</p> <p>19 A. Oh, it's definitely not 300.</p> <p>20 I'm not that fast.</p> <p>21 Q. Okay. And I apologize for</p> <p>22 calling you Professor Darby Dyar. I will --</p> <p>23 I thought your name was Darby Dyar, so I</p> <p>24 apologize for that, ma'am.</p> <p>25 A. Thank you.</p>	<p>1 A. Very little, but I probably</p> <p>2 spend 3,000 hours a year in a laboratory</p> <p>3 using all of the same techniques that are</p> <p>4 used to identify asbestos in talc.</p> <p>5 Q. Very little. Is that less than</p> <p>6 ten hours?</p> <p>7 A. Probably.</p> <p>8 MR. FINCH: No more questions.</p> <p>9 MR. CHACHKES: That's it.</p> <p>10 VIDEOGRAPHER: Okay. Stand by,</p> <p>11 please. One second. Remove your</p> <p>12 microphones.</p> <p>13 The time is 6:45 p.m. This</p> <p>14 completes today's deposition.</p> <p>15 Off the record.</p> <p>16 (Deposition concluded at 6:45 p.m.)</p> <p>17 -----</p> <p>18</p> <p>19</p> <p>20</p> <p>21</p> <p>22</p> <p>23</p> <p>24</p> <p>25</p>

Melinda Darby Dyar, Ph.D.

<p style="text-align: right;">Page 366</p> <p>1 CERTIFICATE</p> <p>2</p> <p>3 I, CARRIE A. CAMPBELL, Registered</p> <p>4 Diplomate Reporter, Certified Realtime</p> <p>5 Reporter and Certified Shorthand Reporter, do</p> <p>6 hereby certify that prior to the commencement</p> <p>7 of the examination, M. Darby Dyar, Ph.D. was</p> <p>8 duly sworn by me to testify to the truth, the</p> <p>9 whole truth and nothing but the truth.</p> <p>10 I DO FURTHER CERTIFY that the</p> <p>11 foregoing is a verbatim transcript of the</p> <p>12 testimony as taken stenographically by and</p> <p>13 before me at the time, place and on the date</p> <p>14 hereinbefore set forth, to the best of my</p> <p>15 ability.</p> <p>16</p> <p>17 I DO FURTHER CERTIFY that I am</p> <p>18 neither a relative nor employee nor attorney</p> <p>19 nor counsel of any of the parties to this</p> <p>20 action, and that I am neither a relative nor</p> <p>21 employee of such attorney or counsel, and</p> <p>22 that I am not financially interested in the</p> <p>23 action.</p> <p>24</p> <p>25</p> <p>_____ CARRIE A. CAMPBELL, NCRA Registered Diplomate Reporter Certified Realtime Reporter Notary Public Dated: April 3, 2019</p>	<p style="text-align: right;">Page 368</p> <p>1 ACKNOWLEDGMENT OF DEPONENT</p> <p>2</p> <p>3</p> <p>4 I, _____, do</p> <p>5 hereby certify that I have read the foregoing</p> <p>6 pages and that the same is a correct</p> <p>7 transcription of the answers given by me to</p> <p>8 the questions therein propounded, except for</p> <p>9 the corrections or changes in form or</p> <p>10 substance, if any, noted in the attached</p> <p>11 Errata Sheet.</p> <p>12</p> <p>13 _____ DATE</p> <p>14 M. Darby Dyar, Ph.D.</p> <p>15</p> <p>16 Subscribed and sworn to before me this</p> <p>17 _____ day of _____, 20 ____.</p> <p>18 My commission expires: _____</p> <p>19</p> <p>20 Notary Public</p> <p>21</p> <p>22</p> <p>23</p> <p>24</p> <p>25</p>
<p style="text-align: right;">Page 367</p> <p>1 INSTRUCTIONS TO WITNESS</p> <p>2</p> <p>3 Please read your deposition over</p> <p>4 carefully and make any necessary corrections.</p> <p>5 You should state the reason in the</p> <p>6 appropriate space on the errata sheet for any</p> <p>7 corrections that are made.</p> <p>8 After doing so, please sign the</p> <p>9 errata sheet and date it. You are signing</p> <p>10 same subject to the changes you have noted on</p> <p>11 the errata sheet, which will be attached to</p> <p>12 your deposition.</p> <p>13 It is imperative that you return</p> <p>14 the original errata sheet to the deposing</p> <p>15 attorney within thirty (30) days of receipt</p> <p>16 of the deposition transcript by you. If you</p> <p>17 fail to do so, the deposition transcript may</p> <p>18 be deemed to be accurate and may be used in</p> <p>19 court.</p> <p>20</p> <p>21</p> <p>22</p> <p>23</p> <p>24</p> <p>25</p>	<p style="text-align: right;">Page 369</p> <p>1 -----</p> <p>2 ERRATA</p> <p>3 -----</p> <p>4 PAGE LINE CHANGE/REASON</p> <p>5 _____</p> <p>6 _____</p> <p>7 _____</p> <p>8 _____</p> <p>9 _____</p> <p>10 _____</p> <p>11 _____</p> <p>12 _____</p> <p>13 _____</p> <p>14 _____</p> <p>15 _____</p> <p>16 _____</p> <p>17 _____</p> <p>18 _____</p> <p>19 _____</p> <p>20 _____</p> <p>21 _____</p> <p>22 _____</p> <p>23 _____</p> <p>24 _____</p> <p>25 _____</p>

Melinda Darby Dyar, Ph.D.

Page 370		
1	-----	
2	LAWYER'S NOTES	
3	-----	
4	PAGE	LINE
5	---	---
6	---	---
7	---	---
8	---	---
9	---	---
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11	---	---
12	---	---
13	---	---
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18	---	---
19	---	---
20	---	---
21	---	---
22	---	---
23	---	---
24	---	---
25	---	---

A	97:2 113:23	180:12	110:13,20	airborne 4:23
a.m 1:15 8:5	163:20 164:6	address 12:10	111:13,18	67:23 135:21
60:20,21,23	215:3 288:9	12:15,24 46:12	112:6,11	136:10
121:22,23	301:4,15,17	157:3 255:18	113:22 114:1,4	al 4:24 5:13,17
122:1	accreditation	addressed 364:5	114:25 124:14	93:14 185:4
aberration	53:14	adequate 340:16	128:5 130:22	292:25
274:21	accredited 53:4	Adirondacks	131:4 132:20	Alabama 2:5
aberrational	53:8,10	191:18	133:3 134:21	102:18
274:16 275:1,6	accumulate	adjusts 209:3	155:19 163:18	Alamos 52:11
ability 41:7,13	324:14	administer 9:14	167:24 170:15	Alex 2:16 8:25
163:15 275:3	accuracy 84:5	Administration	171:2,14,24	285:4
366:9	298:24 299:7	341:15,16	177:22 178:8	Alice 102:9,12
able 117:24	345:5	admittedly	178:18 181:13	174:7
152:14 176:2	accurate 149:23	214:19	182:24 184:11	align 40:11
178:5 183:5	163:16 229:16	Advanced 52:9	184:23 206:22	alignment
188:12 190:10	233:23 275:17	advantage 111:5	206:25 208:20	208:17
195:12 196:7	305:8 361:1,20	advisement	208:23 210:16	ALLEN 2:3
213:25 215:16	367:18	38:13	210:18 211:25	allow 84:5
215:25 216:8	accurately	aerially 175:22	215:19 230:9	182:10 196:19
233:8,16	125:4,21	affect 75:4 275:2	233:6 239:9	236:18 270:24
237:17 251:19	achachkes@o...	275:23 276:5	240:5 242:6	allowed 193:1
253:12 255:25	2:16	affiliated 52:25	247:19 253:21	allows 85:8,10
305:18 348:8	acknowledged	122:9	255:10 266:7	181:14 196:14
absence 84:18	299:9	affirm 225:2	266:12,17,25	196:21,22
124:22 342:16	ACKNOWLEDGE...	affirmative 19:5	276:16 289:21	234:25
342:19	368:1	affirmed 67:11	291:15 301:3	alluding 160:9
absolute 325:13	acquire 141:7	afternoon	302:3 312:23	alpha 291:8
absolutely 30:20	143:10	161:15 213:16	313:25 314:5	altered 174:18
130:6 138:22	acquisition	308:13	314:12,18,19	Aluminum
182:14 269:3	326:4	age 9:18	316:11 318:16	155:8
abundance	actinolite 79:3	agency 47:21	325:7 333:22	Amazon 354:22
277:3	89:20 91:19	68:2 99:3	334:15 336:3	Ambient 4:19
abundances	140:16 145:13	359:6	337:23 339:8	ambiguity
182:6	151:2 173:16	ago 53:17 98:21	346:15,20	209:18 210:12
academia 358:8	174:20 319:16	120:9 153:7	351:13 352:6	ambiguous
academic 53:9	338:25 345:17	193:8 233:20	352:15 364:2	137:12 204:16
222:20 295:12	action 279:2	345:4 348:5,7	agreed 260:1	America 122:9
accept 288:4	366:12,13	348:25 349:1	343:22	177:10 358:23
acceptable	activity 43:13	359:12	agreement 7:24	358:24
190:1	actual 226:21	agree 63:25	352:12	American 49:1
accepted 125:10	235:2,6	64:24 68:11,23	Ah 251:2 281:9	145:21 241:1
188:21 189:16	add 192:22	70:22 81:24	284:21 300:17	Amherst 12:12
access 51:3	added 226:15	84:10 85:4	ahead 27:17	52:13
accessories	addition 102:22	94:8 96:16	231:15 242:10	amosite 91:19
288:14	111:3 165:9	99:19 100:2,15	air 4:16,18,19	194:12,18,23
accessory 96:18	additional 27:7	103:13 106:22	49:11,20 61:14	194:24 338:1
	77:7 166:18	107:4,4 109:2	135:18	345:15 347:12

347:23	295:5 322:3	246:12,17,22	118:14 120:20	306:19 307:11
amount 178:19	362:18,20,23	248:9 275:7	123:18 125:14	323:9,11
196:17 275:20	analog s 319:15	277:9 278:2	126:4 127:7	324:16 329:6
amounted 208:1	analyses 58:25	281:23 295:18	128:14 135:16	351:15 359:9
amounts 56:16	72:20 121:7	295:24 305:2	167:20 168:1	359:20 360:9
56:22 100:19	157:6 158:5	311:1 323:6	168:20 171:11	360:24 362:15
163:19 164:6	169:18 193:20	325:22 326:5,5	181:8 186:1	362:18 364:23
181:5 272:14	228:24,25,25	333:3 342:21	187:22 188:25	angle 119:11
276:18	231:4 247:16	351:7,13,21	189:8,19,19	209:21,23
amphibole 5:3,7	249:3 291:13	352:3 355:24	195:22 228:21	244:12
64:16 83:9	297:22 360:5	361:2	229:5,6,15	angles 196:9
89:16 90:23	analysis 5:1,15	analyst 40:2,14	254:10 258:4	200:12 211:16
91:18 92:3,6,9	6:7 30:23	40:21 41:6,16	258:13 260:18	219:23
93:10,15 94:4	32:10 33:8,18	64:10 86:18	263:23 269:17	angstrom
94:25,25 95:15	39:3,12 49:2	119:15 125:13	272:22,24	235:20 236:14
96:6 101:12,22	60:9 63:9	126:4 127:5	331:24 360:12	237:16
107:9 111:9,14	64:16 65:13	137:3,18 196:5	analyzed 17:8	animal 44:6,7
111:17 137:12	66:2 69:1,1,2	207:15 208:12	23:5 39:23	Ann 19:16,17
147:13,15	83:11 106:16	208:24 244:17	48:7 51:19,23	83:7 330:13
150:24 151:1,5	116:14 121:12	255:14 273:5	57:21,22,23	332:14
151:10,21	125:6 126:15	321:6 324:9	58:11 59:18	Ann's 330:17
173:16 194:13	126:16,17	332:4	78:4 86:8,20	Annex 130:20
217:1,11,21	127:1,23 128:1	analysts 41:25	102:5 106:7	131:25 134:22
218:3 219:21	128:2,16,21,24	129:22 158:15	121:14 131:12	announced
226:23 228:5,6	129:1 132:5,6	211:1 245:12	205:13 226:20	173:22
228:7 231:21	136:1,14,18,19	249:14,20	247:22 257:17	annual 349:4,13
240:14,23	136:21 137:9	253:8 254:7,8	273:18 281:2	350:3 364:23
286:4 294:8,12	137:20 138:4	255:2,12,13	331:9	answer 10:18
295:1 302:21	138:19,20,25	272:22,24	analyzes 101:24	30:11 36:25
303:8 319:3,18	141:13 142:5	278:2 292:13	124:16 325:23	37:10,18 55:10
320:1,4,7,12	145:3,25 146:2	305:22 317:5	analyzing 16:24	70:4 76:23
320:16,21,25	150:13 156:2	325:4 331:11	17:21 23:25	80:16,23 82:12
322:8,18,19,22	169:17 171:15	331:12	43:23 54:4,8	95:20 99:1
324:11,22,24	177:2,18 178:6	analytical 52:21	54:12 55:6	102:3 109:9
325:2,5 358:16	179:4,7,13,18	131:16 146:17	56:2 64:9	124:3 162:18
362:11,12,14	186:23 187:21	165:12 166:13	66:12 69:8	163:15 164:15
amphiboles	188:23 191:6	172:4 195:10	70:2 73:8 78:1	165:5 185:15
44:18 45:1	192:11 193:6,9	203:17 265:2	104:5 108:1	188:18,19
86:9 89:19	193:21,25	336:11 341:3	119:8 130:11	198:14 219:11
90:11 94:19	194:3 195:16	361:11 362:21	137:7 154:2,14	220:18 232:4
111:6 140:13	197:6,7,8,9,25	analyze 7:9 23:6	170:18 193:11	253:13 267:9
173:24 204:16	200:21 202:3	24:12 41:8	194:3 195:22	267:10,12
219:16,25	203:1,25	51:7 56:21	201:7 215:15	268:7 275:10
227:2 240:10	204:14,15,17	59:14 66:10	221:21 237:21	276:10 277:19
256:20,24	204:18 207:22	101:19 103:15	265:5,9,17	317:1 334:4
257:10 259:2	207:24 232:22	106:3,24 117:9	268:19,25	335:1 340:19
261:24 262:2	240:25 245:11	117:10,14,18	285:24 295:7	350:16

answered 85:19 314:23	107:11 227:6 334:14	125:23 304:1	353:9 362:23 364:25	112:14,19,20 113:9 114:5,17
answering 55:1 268:22,25	appear 32:17 247:1 287:8	Argonaut 88:6 174:23 177:3 177:18	asbestos 4:20,23 5:4,9 6:12,13	115:2,2,13 118:16 123:6
answers 219:8 276:14 368:5	appearance 187:1 274:23	arguing 321:17	17:22,22 18:25 19:7 20:12	123:10,14,19 124:5,16,20
Anthony 253:22	appearances 4:3 8:12	Arizona 349:21	24:1,12 35:5 46:14 47:1,6	125:16 126:6 127:8,10 128:1
anthophyllite 79:2 89:21,22	appearing 207:12	ARPS 1:14	47:12,17,23 48:5,10,16,23	128:14,15 129:2,4 130:1
89:23 90:4,9	appears 20:1 59:2 156:7,13	arrangement 182:17	49:2,10,15,20 49:24 50:3,8	130:5 131:1,21 132:7,14,16
90:18 91:5,15	162:6 180:11	array 208:16 219:5	51:16,21 54:1 54:5,9,13,17	133:6,8,15,17 133:23 134:4,5
91:19,23,24,25	208:13 225:17	art 42:6,21,21 43:1	55:8,11 56:3,5 56:8,17,22	134:10,12 135:17,21,23
93:22 94:9,9	applications 71:13 214:3,22	article 144:4 146:10 333:11	57:21 58:1,4,7 58:9,12,14	136:2,7,11,23 136:24 137:22
94:17 95:5,23	applied 106:14 304:12	344:15,16	59:16 60:11 62:5,10 63:2	138:2,20 144:17 146:2
112:19 114:5	applies 187:9	articles 47:4	63:13 64:5,6,9 64:16 65:3,21	146:15 158:13 158:23 159:22
114:17 115:2	apply 70:14	articulated 54:19 115:17	66:12 67:24 69:3,8 70:3,16	159:23 160:22 171:16,21
124:7 130:25	appropriate 34:1 57:3 59:5	artifacts 145:17	70:24 71:3,14 71:17,23 72:9	173:24 180:24 181:24 184:24
140:17 145:13	106:3 125:23	asbes 51:20	72:25 73:9,21 74:14,15 76:9	187:5 193:12 193:17 194:3,5
158:13 159:23	132:5 142:25	asbestiform 6:8 19:6 78:22	76:10 78:16,17 78:19 79:7	195:7,22 196:20 197:12
181:4 185:10	143:1 147:15	79:14 84:6	81:3,7 82:9,23 83:12,20 84:13	197:13 198:3 198:11,19
185:14 206:20	149:7,15,25	95:17 99:10	85:9,14,16 86:5,10,12	200:19 201:24 202:4 204:20
206:23 207:1,5	152:4,16 158:7	108:22 111:6	89:17,18,21 90:4,18,20,24	206:20,23 207:11 212:3
207:11 212:2	208:1,4 240:22	111:16 138:12	91:5,7,12,23 93:24 94:5,10	214:2 215:18 215:21 216:5
212:13,17	264:2 323:6	138:12 139:13	95:11,16 97:14 97:22 98:5,10	217:15,19 219:2 221:22
217:13 240:6	333:1,6 367:6	139:14 173:18	99:20,25 100:4 100:10,19	227:10,19 228:9,12 231:8
241:19 245:15	approved 29:9 93:11	174:19 185:3,8	101:19,20 103:7 106:25	231:10,21 232:23 233:8
245:20 247:2	approve 226:22	185:11 187:11	107:2 108:2,6 110:16,22	233:23 243:24 244:23 258:6
247:21 248:15	approximate 226:22	187:15 188:6	111:23 112:7,8	260:6 261:3
250:9,16 251:4	approximately 7:6 150:6	189:20 194:14		
251:9,15	204:12 349:4	197:2 262:1,6		
252:10 253:24	April 1:8 6:10	263:21 269:25		
255:12 280:19	8:4 36:16,18	293:1,3,6		
285:6,17 287:7	366:19	295:9,17 296:4		
289:11,16	apologize 363:21,24	303:8 310:9		
319:16 338:20	apologize 363:21,24	311:2 318:9,18		
338:21 345:16	apologize 363:21,24	319:3,14		
anybody 348:23	apologize 363:21,24	321:17 322:3		
anybody's 159:6	apologize 363:21,24	323:23 324:10		
anyone's 192:12	apologize 363:21,24	325:5 328:23		
apologize 363:21,24	apologize 363:21,24	331:6,14		
apparati 238:1	apologize 363:21,24	341:24 342:17		
apparatus 234:24	apologize 363:21,24	351:8,15,22		
apparent 86:10 212:3	apologize 363:21,24			
apparently	apologize 363:21,24			

262:10,12	273:7	324:4,6,16,19	93:13	153:19 155:20
263:21 264:15	asbestos-related	324:25 325:20	assorted 207:12	159:24 175:12
264:24 265:5,9	99:11	325:23 326:10	assume 13:23	347:22
265:18 266:9	Asia 170:10	327:3,7,7,11	144:22 231:2	available 35:18
266:14,19	aside 77:10	327:15,18	260:15 263:17	35:20 60:2
267:2,8,17,22	221:13	328:2 329:1,6	330:11,11	102:23 160:8
267:25 268:3,5	asked 16:15,17	329:7,12,16,18	356:11	263:11,15
268:9,15,21	16:21 21:22	331:24 332:1,2	assumed 276:13	327:11 349:7
269:2,8,11,23	22:1 25:4	332:9 333:20	291:7	Avenue 2:12
270:8,16,25	47:20 57:10	aspects 187:4	assuming 99:21	average 217:17
271:19 272:3	69:24 74:22	assemblages	109:16 211:22	321:10,19,20
272:11 273:6	75:2 76:19	114:8 164:2	271:12,13	321:21,24
275:3,22 276:3	85:18,20 98:17	191:1	assumption	322:19 323:12
291:15 292:14	98:18 113:16	assertion 113:15	305:1	324:4,5 329:7
294:20,22	115:14 120:8	226:13 248:2	assumptions	award 359:3,3,6
295:9 296:4,12	124:2 159:13	253:17	231:18,24	awards 358:19
296:14,19,25	194:25 216:6	assertions 252:1	ASTM 49:6	359:1
297:2,9,17	232:7 253:3	assertive 331:22	asymptotic	aware 24:8
298:15,22	258:2,8,12	asserts 104:16	322:5	51:15 68:4
302:13,14	263:19 264:5	185:6	ATEM 89:14	73:19,24 74:9
303:14 304:13	273:11 297:11	assess 76:1	atoms 181:19,22	74:13,19 94:3
305:9 306:23	314:22 356:24	255:2 335:22	182:18 200:7	95:14 99:8,13
307:11 308:2	asking 30:2,4	341:7 342:6	200:10 209:9	102:13 104:21
309:4 310:8	115:21 118:14	assessing 54:16	attached 6:19	105:4 108:19
314:20 315:12	230:17 267:23	101:8 249:13	22:25 313:3	128:10,16
316:15 317:7	287:5 338:4	assessment 83:3	357:9 367:11	135:6 174:13
317:25 320:7	asks 10:13	179:1 193:18	368:7	184:21 217:4
320:16,25	aspect 72:16	193:24	attempted	310:1,12,14,20
322:23 325:2	82:21 83:4	assign 253:7	207:25 297:16	310:24 311:5
329:6 330:21	183:16,19,21	assigned 142:2	attempting	311:13,14,18
331:6 333:25	183:23 184:1	248:1,24	297:8	311:24 316:18
334:12,17,19	185:17,20	252:23 253:2	attended 222:9	316:21 334:10
335:9,19 336:8	186:6,25 187:8	assignment	222:14	336:16
337:3,24	187:13,16,23	252:16,20	attention 51:12	axes 70:8 199:18
339:10 340:24	189:19 193:21	assignments	103:24 147:12	243:20 244:1
341:17 342:25	193:23 217:17	313:8	249:11 273:23	245:3 259:13
344:16,19,24	218:19 221:25	associate 145:20	attorney 366:11	261:9 264:12
345:24 346:16	261:18 267:16	associated	366:12 367:15	269:14,15
347:1,13,23	269:16,24	140:12 326:3	attorneys 29:14	axis 69:14 72:19
350:21 352:17	270:3 315:20	associates 5:22	author 20:2 49:1	115:24 116:13
362:8,11 364:6	316:19 317:21	6:1 214:19	49:6,13,18,22	136:14 200:11
364:10,14,19	318:22 319:19	221:17 222:10	59:9,10 101:24	200:13,20
364:25 365:4	320:3,5,9,13	223:5 224:10	355:15	201:5 202:2,25
asbestos-cont...	320:22 321:2	225:15 227:18	author's 153:17	203:10,19
74:5 132:9,22	321:10,21	228:23 257:6	authored 47:8	207:23,24
133:10,12	322:10,15,20	258:14	authors 75:2,18	208:9,17
134:1 135:8,9	323:12,21,25	association	144:11,25	211:12,20,24

219:23 260:5 263:13	230:10 246:4 278:13	277:14 295:12 317:22 318:22 331:17 350:4 364:23	best 21:9 83:5 107:16 128:2 138:21 182:19 195:16 318:7 366:9	103:4 107:7 BNSF 123:2 body 43:14 bomb 348:8 book 20:8 147:6
B	backward 224:5 backwards	basketball	better 32:24 39:24 41:20 60:10	147:24 148:19 148:24 167:16 167:19 181:12 184:16 189:10 201:9,17,17 218:14 240:12 355:3,11,15
B 22:25 140:15 155:4 185:2 186:14,15 312:20 316:6	238:5 250:21 281:8	312:21	beyond 114:22	books 201:14 353:24 354:3,8 354:10
BA 42:24	bad 179:25 241:18	Bates 165:18 166:5	bias 75:4 172:8 252:20	bother 166:7 bottles 248:7 bottom 123:23
baby 17:16 18:1 19:2,9 44:14 69:18 77:15,17 87:25 96:21 103:7 113:6,7 166:25 220:25 231:6 232:9	Badollet 6:14 344:15	beam 150:14 209:10	Biddle 2:19 9:4 9:7	125:1 150:18 179:22 210:5,6 226:8 238:4 245:18 247:11 280:12 331:3 337:16
bachelor's 42:20	Ballpark 363:17	bear 18:19 62:9 110:15 174:23	biases 323:22	box 331:13 boy 186:15
back 13:14 22:25 26:11 48:1 51:13 54:18 55:19 60:22 61:2 64:13 66:9 86:22 96:17 121:25 126:8 139:10 161:12 161:16 189:1 204:23 212:18 213:13,17 225:19 227:8 253:7 256:9,12 295:14 302:5 303:7,20 308:10 317:2 317:18 319:22 321:8 325:16 328:9,13 339:24 340:17 343:13,18 357:10	Bank 2:13 barely 222:25 based 7:10 97:24 100:7 112:12 125:22 130:1 140:14 140:19,20 142:1 145:20 157:10 158:8 158:10,14 159:4 162:6 172:3 179:7 188:5 213:22 215:15,20 231:17 248:15 292:9,15,18 294:2 295:18 322:12	beginning 24:15 28:16 73:6 303:18,22	big 119:3 125:17 175:21 271:12	197:20 250:2 296:9
back 13:14 22:25 26:11 48:1 51:13 54:18 55:19 60:22 61:2 64:13 66:9 86:22 96:17 121:25 126:8 139:10 161:12 161:16 189:1 204:23 212:18 213:13,17 225:19 227:8 253:7 256:9,12 295:14 302:5 303:7,20 308:10 317:2 317:18 319:22 321:8 325:16 328:9,13 339:24 340:17 343:13,18 357:10	bases 25:7 basic 120:3 124:9	begins 319:9 behalf 8:22 9:1 9:4,9,21 15:16 20:13 21:5 28:24 29:15	biological 43:13 biologist 43:17 43:20	break 26:6,9,14 57:15 60:18 61:3 77:7 112:4 120:9,11 158:25 161:6 161:17,19 213:18 218:1 243:2,5 256:3 256:13 306:12 308:5 343:19 357:16
background 80:23 169:3,10 279:1 287:23 288:13,17 293:12	basically 28:4 30:5 41:12 151:8 201:20 274:21	believe 14:3 16:8 19:17 24:7 27:13 76:22 84:16 87:18,19 89:2 93:8 101:5 108:17 124:1 133:9 136:2 182:3 184:15 192:14 205:4 205:14 210:19 221:10 232:19 240:8 252:19 273:2,8 290:14 313:19 325:12 326:1,14 332:13 335:10 341:1 343:22 351:2 353:13	biomineraliza... 359:24 360:16 bit 21:24 26:2 70:10 91:22 212:9 218:1	breakdown 30:17 50:21 255:11
backup 32:24 33:4 88:20	basis 11:15 54:4 54:8,12 141:1 150:23 151:8 151:14 160:13 165:19 187:25 193:6 199:9,21 210:23,25 211:6,8 214:7 216:14,19 231:18 247:4	belong 240:20 belongs 187:14 belt 156:10 162:8 163:11 bend 79:25 bending 252:1	black 174:23 282:11,13,17 blah-blah-blah 203:18 blocky 173:20 Bloss' 201:16 Blount 5:8 101:9 102:10,14 106:10,15,20 106:23 107:5 107:15,18 108:10,14,16 108:19 109:11 111:3 174:7 272:3,9 273:18 274:5,9 Blount's 102:25	breaking 213:4 213:7 bredigite 191:9 192:4 brief 82:2

259:10 260:9	296:5,15,22	61:4 68:25	294:7 295:13	137:11
briefly 77:10	312:18,24	105:3 106:9	297:16	Causation 4:14
bring 111:4	313:1,21,25	109:17 118:17	careful 116:10	22:20
325:16 353:24	314:15 316:2	144:21 173:2	293:13 295:18	cause 43:24 96:9
354:3 356:6,12	Bureau 51:16,20	236:12 310:5	315:25	99:10
356:21 357:3	buried 249:9	314:2 348:2	carefully 17:7	cell 43:17,20
broad 214:4,9	business 12:10	calling 292:13	146:20 259:10	356:11
214:23 215:2	53:12	347:23 363:22	367:4	cement 133:15
216:20 217:9	butcher 50:11	calls 73:25	Carolina 102:18	center 51:2
brought 62:9	153:18	camera 234:21	Carrie 1:16	52:23,24
354:7 355:16	buy 354:18	234:23 235:5	366:3,17	centrifugate
355:17 356:10		235:11,14,23	Caryl 21:18,18	303:9
356:11	C	236:12,12,12	28:9	centrifuge 303:5
buildings	C 2:1 140:16	236:22,23	case 5:16 10:20	certain 165:17
133:17	150:12 157:24	237:13 238:1,3	10:23 11:1,4	169:16
builds 137:14	186:9 316:6	238:10,14,17	13:16 15:14	certainly 26:23
Built 5:9 309:5	319:21 322:13	239:11,13	18:22 20:19	71:1 80:2 82:6
bulk 4:17,18	324:5	Campbell 1:16	21:25 22:9	85:25 86:9
49:10,16 56:5	Cal 358:7	292:25 311:10	23:4,15 33:18	105:2,24 108:3
56:11 62:5	calcite 66:6	366:3,17	34:5 36:22	115:8 117:12
63:2 64:5 65:4	calcium 115:25	Campion 18:13	38:7 56:4	124:21 134:25
131:20,23	117:1 173:17	Campion's 34:3	62:14 68:16	139:7 141:23
133:7,22,24	191:12	34:17	102:4 122:5,11	146:20 174:19
134:1,3,4,9	calcium-beari...	Campus 2:22	131:10,18	176:4 181:11
135:18 171:15	218:4	Canada 359:5	132:17 153:9	198:15 201:17
273:7 364:10	calculate 81:21	Canadian 225:7	156:16,19	205:24 237:9
bullet 124:25	141:7,9 142:6	cancer 6:10 8:15	169:20 215:2	242:5 243:7
bundle 111:22	234:21 327:3	10:4 43:25	215:12 231:8	257:24 301:6,9
111:24 178:15	327:11,18	62:24 96:10	232:7 243:12	301:16 330:17
184:16,21	calculated	99:4 103:2	249:18 250:11	350:6 353:3
185:3,9,11,14	140:22 141:3	160:22	277:6 286:19	360:20
185:22 187:2	141:12 143:12	cancers 99:11	287:7 289:1	certainty 320:2
196:6 227:2	209:23 304:4	capable 124:17	297:12,25	320:8 321:1
293:23 297:24	304:10 328:25	caption 140:21	305:18 322:2	CERTIFICA...
297:24 313:6	calculations	155:24	328:19 330:16	366:1
313:17 314:6,8	28:1 125:22	capturing 40:25	332:18,22	Certified 1:17
314:20,21	143:4,15 247:8	Car 5:2	334:14 342:21	366:3,4,18
316:23 317:24	329:2	carbon 225:21	347:20 354:5	certify 366:4,7
317:24 335:9	calibrated 53:15	226:3 346:18	356:14,22	366:10 368:4
335:19	234:24	carcinogenic	cases 1:7 15:18	cetera 136:15,15
bundles 49:3	call 21:11 39:2	44:15,20 45:2	19:21 23:19	198:3,4 199:2
101:20 111:7	68:12 74:23	care 3:4 9:12	62:24 63:20	199:3 220:17
111:14 184:12	155:20,21	53:22	67:7 74:4	220:17 299:10
184:13,22,24	314:3	career 48:9	160:22 165:20	299:10
185:7 226:25	Callan 254:10	50:15 51:25	283:8 304:22	Chachkes 2:16
292:13 294:8	called 10:12	62:2 67:2	360:11	4:6 7:14 8:25
294:12 295:9	14:20 59:21	292:4,11,17	categorize	9:1 10:16 11:2

16:11 25:22	284:4,12,19	152:1 336:7,12	267:11 361:12	222:12
26:3,10,25	293:25 294:15	340:24	ChemRisk	classified 173:18
30:1,8 31:9,25	296:8 300:12	characterized	311:17 312:8	204:16
32:11 33:19	302:23 306:7	82:9,22	Chestnut 12:12	clear 24:21
34:9 36:23	306:13 310:10	charge 48:2	Chicago 52:10	141:14 192:14
37:7,17 38:12	311:4,18 312:2	258:7 350:15	China 17:20	237:12 238:16
41:1 46:15	312:13 323:14	charging 145:17	19:8 87:9,17	246:8 269:4
57:12,18 68:6	327:20 329:9	chart 245:19	170:5 192:18	316:17,17
71:8 74:7,17	332:3 334:1,21	337:20 338:17	192:20 248:9	340:2
76:15 83:2	339:1 341:19	check 28:4	choose 125:3	clearly 54:20
91:9 94:1	342:2,23 350:5	243:3,5	155:5 232:3	132:17 287:19
95:13 96:1	351:17 352:8	checking 36:11	Choosing 151:1	287:23 288:8
100:20 103:20	352:19 353:12	checks 14:11	Chris 21:18	291:3
105:14 109:6	354:12,20	chemical 5:14	Christopher	cleavage 178:15
109:25 110:18	355:17 357:14	72:3 83:21,25	28:9	291:23 292:2,5
112:2 113:11	357:18 363:8	84:11 90:15	chronological	292:9,10,14,16
115:3 120:8,14	365:9	94:17,20 95:6	224:5	293:9,12,15,23
120:25 132:24	chain 104:3	95:7 124:19	chronology	294:6 298:2
141:19 158:18	249:10	125:5,14 126:5	87:14	310:7 316:23
159:1,10,14	chain-of-custo...	127:8,15,19	chrysotile 79:3	317:25 335:8
160:2,15,24	103:23	128:15,21	133:14,16	cleavement
163:4,22 164:9	challenge	129:2,8,12,13	137:14 145:14	335:7
168:10 170:6	362:24 363:3	129:15,18,24	173:24 207:20	Cleveland 21:12
175:1,14 176:8	chance 19:16	130:4 131:6	338:1 345:15	Clifton 174:25
179:9 180:19	189:14	137:6,9,21	citation 299:4	175:4
186:11 191:23	change 207:9	138:3 145:24	citations 79:10	Clinical 153:13
197:17 208:2	212:5 274:23	146:2 149:20	202:7 245:5	close 139:17
213:2,8 214:12	283:3 285:16	149:23 151:5	cite 49:8 80:8	closest 291:8
215:5 216:2,23	288:16	152:1,13,17	139:24 142:23	clump 216:5
217:23 220:9	CHANGE/RE...	156:17 158:5	199:16 205:20	coating 145:16
221:7 223:13	369:3	177:17 179:4,7	213:24 356:2	coauthor 59:7
223:16 224:25	changes 209:5	179:15,18	cited 17:10	153:3
226:1 229:2,17	363:14 367:10	181:8 194:4,6	77:11 101:5,9	coauthors 153:2
230:12 231:15	368:6	194:9 195:6,13	108:20 110:25	code 254:22
231:22 233:1	changing 296:21	197:6,14	119:22 140:4	COHEN 2:11
233:10,25	chapter 147:24	217:13 228:24	160:6 165:25	coincide 279:11
234:13,19	149:12 181:11	260:18	189:2 330:17	Colgate-Palm...
238:20 239:16	184:16	chemically	334:6 344:16	122:14
242:13 243:1	characteristic	207:5 218:2	357:8	collaborated
244:3 246:7,11	145:14 315:12	chemistries 92:4	cites 109:3	46:7
246:14 248:18	characteristics	chemistry 39:6	City 48:19	collaborations
252:13 253:10	65:16 78:21	39:8 116:5,23	claims 131:3	76:7
256:4 257:21	184:18 315:14	116:24 123:23	174:3	colleague 69:22
258:17 259:7	316:1,13	131:12,13,15	clarify 51:8	collect 332:6
260:24 261:19	318:19,20	138:15 149:15	class 222:9,14	collected 191:17
263:3,7 282:8	319:21 336:13	149:19 207:4	297:5	200:15
282:18,20	characterize	240:23 267:10	classes 222:2,3,6	college 42:22

45:24 53:2 349:7 color 254:22 279:1 283:4,5 288:17 colors 278:21 279:3 287:1,3 287:22 288:16 column 144:25 145:8,8 227:9 combination 115:16 233:5 264:18 270:11 combine 197:5 combined 72:19 115:24 come 14:11 26:11 32:19 34:7 44:7 45:14 46:2 71:21 83:17 139:17 168:2 201:14 226:25 255:25 339:19 comes 17:4 216:21 300:2,4 comfortable 349:9 coming 156:6,8 218:23 260:22 command 142:11 commencement 366:4 commencing 1:15 comment 18:17 105:25 176:22 180:14 234:5 commented 18:15 comments 31:20 33:17 317:10 Commerce 2:4 commercial 62:5 63:2 64:5 65:4 132:10	133:24 134:4 180:2 230:1 commission 368:17 committee 8:23 Commodity 6:11 333:19 334:12,16 common 112:7 192:24 202:8 202:16 218:11 225:20 244:6 commonly 140:4 commonplace 356:4 communicated 332:17 communicatio... 32:2 34:12 companies 6:15 122:10 351:6 company 14:20 28:25 122:24 123:17 173:2 227:5,21 237:25 310:4 company's 257:14 compare 78:2 131:22 305:25 345:22 349:12 350:2 compared 204:18 209:22 273:19 276:21 277:12 337:25 347:2 353:7 comparison 346:5,6 comparisons 306:1 compensated 13:22 14:19 compensation 349:11,25 350:3,7,11	compile 253:14 complaint 237:11 complete 208:7 completed 191:6 completely 53:10 235:24 239:17 274:2 338:5 completes 365:14 complicated 92:4 complies 204:10 235:10 composed 313:2 composition 72:3 94:22 127:15,20 129:8,14,15,18 129:25 137:6 137:21 139:9 140:25 141:8 141:10 145:1 145:15 148:14 148:15,17 149:20,23 152:1 156:18 156:23 179:15 181:8 194:4,6 194:10 195:6 195:13 197:7 197:15 219:7 260:18 269:5,6 291:20 337:7 compositions 84:8 125:5 140:23 142:3,6 142:12 143:11 145:10 148:12 199:1 comprehensive 240:25 computer 210:9 concentration 226:22 233:9 298:15	concentrations 84:21 272:2 concern 137:13 171:9 173:25 174:10 concerning 47:9 conclude 239:12 239:12 253:4 269:11 278:24 288:9 concluded 99:9 319:25 320:6 320:15,25 322:22 325:1 365:16 concludes 179:6 179:11 concluding 211:7,8 conclusion 71:22 104:4 163:2,12 179:15 180:23 210:25 216:14 248:22 298:20 329:4,11 conclusions 17:14 22:9 27:25 34:7,16 78:3 105:10 140:23,25 147:2 175:13 190:11 201:22 243:21 257:19 258:14 260:1 263:6 325:20 342:12 conclusive 188:4 condition 209:12 conditions 208:18 287:3 287:20 confer 31:1,6,12 33:7,12 confidence 190:10 197:11	262:15 confirm 115:25 127:20 139:12 158:22 183:10 239:6 confirmation 243:25 confirmed 231:9 262:10 confirming 138:1 156:15 200:18 conflicts 75:3 confused 193:5 confuses 176:18 confusing 278:9 conjectural 239:18 conjecture 252:19 conjunction 71:19 85:7 268:1 connection 13:16 15:17,25 19:21 20:4,18 23:19 27:9 31:2,7 34:4 35:5 38:6 66:21 84:14 103:1 161:22 227:25 consider 31:23 43:20 80:12 81:9 115:8 165:13 229:14 256:17 257:2 278:6 291:23 306:5 340:22 342:7,14 343:1 347:6 considerable 11:22 349:21 considerations 317:11 considered 81:12 321:16
---	---	--	---	--

342:15 considers 333:25 341:24 consist 188:15 205:11 consisted 248:6 257:15 consistent 79:7 82:23 125:15 130:4 137:22 156:16 157:6 179:8,16,19 190:19 197:13 206:1 217:15 217:19 219:1 240:9 244:23 253:23 255:3 316:14 328:22 consistently 79:11 265:12 292:8 consists 203:17 consolidate 11:24 constant 24:22 234:10,22,23 235:5,14,24 236:17,23 237:13 238:10 238:14,17,24 239:13,20 constants 238:1 238:3 constitutes 293:14 334:18 constrain 79:21 151:19 constraints 156:5,22 196:16 215:11 consult 67:3 consultant 33:21 48:19 consulting 11:22 122:4,8,14,17 122:20,23 123:2	Consumer 6:15 14:16 351:5 contact 44:8 46:2 contacted 13:13 15:16 21:4,7,8 28:8 contain 54:5,9 54:13 100:4,18 108:2 114:2 148:3 154:16 163:25 164:5 167:6 191:11 214:2 215:18 221:13,22 291:22 364:25 contained 17:22 27:15 48:5,16 48:23 50:3 57:21 58:14 88:25 113:8 131:24 155:11 176:5 229:11 292:2 Containers 5:2 containing 132:23 133:16 154:12 contains 22:8 50:7,25 54:17 55:7 56:3 57:25 108:3 115:13 123:6 123:10,14,19 133:8 179:14 263:21 269:22 270:8 contaminant 112:8 162:24 173:14 contaminants 221:23 contaminated 97:13,21 98:4 98:9 99:9 104:14 106:25 112:19 113:22	114:5,17 115:1 contamination 105:21 181:25 256:21,24 257:10 259:2 contemporane... 231:3 content 5:7 60:10 101:12 262:11 contents 147:23 context 83:6 152:5 176:15 180:11 188:20 206:12 228:19 229:22 230:9 230:18 262:21 299:1 338:5 352:25 continue 7:12 192:23 continuous 90:15 contract 28:24 29:4,7,15 contracted 67:25 contrasting 272:18 contributed 58:24 59:5 contributor 49:14,19,23 convention 143:9 conventional 303:25 304:5 304:10 conversation 21:20 Cook 18:13 copies 25:23 27:13 61:9 167:16 300:13 354:7 copy 22:24 25:12,25 26:6	26:24 27:1,4 27:14 225:21 225:24 226:3 331:2 copyright 354:16 cores 174:23 corporate 18:7 correct 10:21 11:9,11,12 13:1,23,24 14:2 15:21,23 18:16,23 19:25 20:9,10 22:5,6 22:10 23:22 24:7 28:6,12 28:13 29:15,16 30:24 35:25 36:1 38:8 39:5 39:11,14,22 40:4,13,19,20 41:10,22,23 42:3,6,7,22 43:5,6,8,15 44:20 49:11,12 57:8 59:4,13 59:18,22 62:6 62:16 63:3,16 64:19 65:18,21 66:4,13,19 69:15,19 71:7 71:17,18 75:1 76:24 77:19 81:22 86:15 88:21 89:8 91:16 92:1 94:16 95:4,8 99:22 101:3,14 101:20,25 102:20 105:13 105:25 106:10 106:11,16,18 107:19,22 108:16 109:14 113:9,19,20 116:16,17,20 116:24 117:4	117:15 118:10 118:19 119:9 120:22 123:23 127:24 128:4 129:12 130:17 131:9 134:1 136:19,20,23 137:7 138:17 141:18 143:16 144:18 146:6 148:1,7 150:4 150:9,10,15 151:6 152:2 153:20,24 154:4,22 155:17 156:3 157:21,25 160:23 162:1 164:8 165:10 166:8 167:13 169:7 170:5 175:13 176:10 179:17,23,24 180:2 183:7,8 183:25 184:2,3 185:24 186:13 187:23,24 188:7 192:13 192:21 193:22 194:4 195:8,17 195:18,23 196:10 199:20 200:8,21 202:14 205:22 207:17 214:5 216:1,13,18 221:6,9 222:5 225:16 227:5 228:10,22 232:10 233:24 238:9,19 239:14 241:19 241:20 244:2 249:25 251:5 252:12,14 258:6 259:6 261:9,10,12
---	---	--	---	---

264:22 265:3,6 270:1 271:13 272:17 278:1,5 278:11,12 279:17,18 280:1,25 281:1 281:24 282:7 283:1,13 285:7 285:12 289:12 293:21 294:13 294:21 295:25 296:7 298:15 298:16 302:22 304:11 306:19 306:20,23 307:1 309:23 313:17 314:14 315:4,5 316:4 316:7 317:16 319:23 320:20 321:22,23,25 322:1 323:10 323:13 324:17 324:20 326:15 326:21 327:12 327:19 328:4,9 331:7 332:2,15 332:16 334:8,9 338:25 339:6 342:13,22 345:22 348:8 348:10,14 349:3 355:9,25 364:4,7,8,11 364:12,20,21 368:5 correction 275:13 corrections 89:1 125:23 274:21 367:4,7 368:6 corrective 274:16 275:1 correctly 65:7 65:11 197:20 197:23 225:12 271:1 304:16	320:10,11 correspond 12:21 correspondence 5:18 103:5 175:20 corresponds 12:22 corroborate 109:18 238:12 cosmetic 5:7 101:12 174:2,4 174:8 224:22 225:6 227:22 231:12 cotton 346:8,19 Council 3:4 9:12 counsel 2:14,23 3:4,9 10:20,22 27:2 31:13 32:21 37:9 355:17 366:11 366:12 count 46:9 229:12,12 237:18 263:2 298:25 299:8 302:13 304:5 327:1,12 328:8 328:17 counted 58:18 299:1,9 323:20 327:7 counting 67:10 218:20 282:20 298:14,18,21 299:25 300:18 302:4,6 303:9 303:20,25 304:11 305:8 305:24 306:22 307:4,6,10 308:1,2 316:1 362:4 countless 63:7 counts 205:8 226:21	couple 12:4 16:5 89:1 course 42:25 48:9 50:14 67:2 78:25 113:25 120:3 164:22 171:7 197:21 207:2 267:8 270:19 271:21 294:24 323:5 360:20 courses 359:13 360:22 court 1:1 9:14 10:15 11:10 25:19 35:5 48:14 55:20 165:8,20 166:3 367:19 courtroom 10:9 180:8 courtrooms 24:10 cover 147:23 covered 295:1 360:20,21 create 189:25 created 11:15,17 11:21 148:13 148:16 193:2 credibility 76:1 criteria 46:19 200:4 203:24 217:22 218:20 219:17 220:6 220:10 316:1 criterion 193:14 criticism 70:15 107:21 238:8 238:15 342:11 criticisms 70:18 104:3 106:13 222:18 223:3 criticize 57:6 64:11 105:9 107:18 criticized	310:25 criticizes 106:19 criticizing 57:10 64:17 critique 358:1 362:7 critiques 333:9 crocidolite 91:20 338:1 339:12 345:16 CROSS-EXA... 357:17 cross-polar 290:5,6 cross-referenc... 227:13 crossed 76:13,16 crowd 19:19 332:15 cryptic 226:14 crystal 41:9 85:11 127:16 182:18 183:10 188:1 194:6 197:8,15 199:2 199:25 200:14 200:16 209:24 210:20 211:10 211:21 241:1,3 241:5 267:11 268:12 337:7 crystalized 60:2 crystalline 71:7 85:6 195:23 196:8 199:19 211:2 244:22 crystallograp... 202:17 crystallography 201:10,17 244:8 crystals 243:13 culminate 362:1 cummingtonite 89:24 92:1 93:21 94:16 95:5,10,22	96:9 240:7 cupboard 105:20 curled 286:20 current 24:20 77:12 240:9 currently 50:23 174:14 curriculum 167:23 custody 104:3 249:10 customer 174:12 cut 300:13 CV 22:24 27:14 27:19 46:10 355:19 Cyprus 173:2,12 174:2,9,10,24 <hr/> D D 2:7 3:14 200:4 200:6 238:24 239:6 240:2 241:3,13 daily 54:4 363:15 Darby 1:12 4:11 4:13 8:11 9:17 9:25 15:4 22:17,19 61:5 61:5,9 88:18 89:11 101:2 147:8 161:15 213:16 256:14 308:13 343:17 351:4 357:20 357:23 363:22 363:23 366:5 368:12 dark 290:24 Dash 65:23,24 data 7:6,10 59:5 66:10 87:18,20 100:8 113:5 125:12,24
--	--	---	--	--

126:3 127:6	367:15	267:16 313:16	130:18 169:13	24:18 38:5
128:12 129:10	DC 2:9 3:3	313:18 314:6	190:7,8,9	40:10 80:9
130:12 131:7	140:13	314:24 317:6	261:21 277:2	101:17 107:23
131:22 137:4	de 174:12	321:14,14	299:8 302:14	303:5 344:18
137:18 138:6,9	deal 58:21	334:18 335:11	deponent 8:10	describing
139:3,16 140:7	207:20	335:14 338:8	368:1	330:20 351:6
140:10,12,15	decade 355:10	352:7,11,16,23	deposed 10:14	description 4:10
140:19,20	decades 359:23	definitions	deposes 9:20	30:6 103:13
141:16 142:1	December 35:22	313:14	deposing 367:14	262:11 315:10
143:5,19 146:5	decide 40:22	definitive 264:7	deposition 1:12	315:13 337:15
148:8 149:4	decided 11:23	331:22	4:11 6:19 7:2	337:19
151:17,23	deciding 40:17	definitively	7:12 8:6 10:6	design 264:16
152:13,17	decision 173:22	268:15	10:12 13:17	designed 66:1
155:5 156:1	245:2 331:22	deformed	14:24 20:16	135:9 264:23
157:24 158:22	declassify	111:23	21:1 22:18	265:1
165:12,22	173:20	degree 43:1	23:14,18 24:5	detail 24:19
166:13 171:4	decompose	107:15 320:2,8	24:16,20 37:3	129:10 142:24
179:22 180:25	212:9	321:1 357:21	37:6 103:1	details 136:13
181:1 191:5	decreasing	357:22 361:21	112:1 128:7	270:20
200:2 218:8	320:3	degrees 41:14	189:15 214:20	detect 48:10
230:10 238:19	deem 166:16	42:5	245:3 247:25	233:8 275:3
239:14 245:23	deemed 367:18	deliberately	248:21 305:25	detected 145:2
246:4,8,13,15	default 142:11	125:2 216:10	308:16 309:22	275:23
246:18,24	Defendant 2:23	demonstrate	309:23 326:2	detecting 70:16
247:6 250:5	3:4	240:1	341:2 356:7,14	362:8
253:18 255:4	defendants	Dennis 2:11	356:23 365:14	detection 63:9
258:16 260:20	73:21 74:14	8:17	365:16 367:3	63:13
305:15 324:14	76:10	denominator	367:12,16,17	detectors 361:6
326:14 327:1	define 39:1	274:6	depositions 24:2	determination
327:10,18,22	79:11,14	densities 107:14	24:4 244:25	4:20 56:5 62:4
332:6 340:6	111:22 183:14	108:5 301:11	deposits 102:16	63:2 178:13
database 218:14	313:5 336:9	301:13,15,18	174:21,25	188:5,12
241:2	defined 78:20	304:7,15	175:5,22,24	199:18 200:20
date 1:16 8:4	111:23 129:4	305:12 307:1	221:2,3,12	202:4 244:21
93:18 247:16	228:16 236:25	307:13	252:4	292:1 302:13
366:8 367:9	314:16 352:9	density 108:8,18	deps@golkow...	302:20 304:12
368:12	defining 5:9	306:18	1:23	determinations
dated 61:17	228:13 309:4	departments	derived 174:17	72:19 115:24
88:16,21 177:5	definitely	53:1	describe 59:23	201:6 202:2
366:19	363:19	depend 55:9,10	64:8 127:16	203:1,11
dates 225:9,10	definition 78:15	188:19 247:22	208:6 257:12	determine 24:1
247:11	78:17 79:8	275:5,7	259:4 302:6	44:8 46:13
Daubert 4:14	83:20 93:17	dependent	described 40:5	47:1 48:4,15
22:20 189:15	110:21 111:25	298:25	54:25 66:2	48:22 50:2,7
day 36:17 260:4	121:1 127:10	depending 39:1	109:12 313:1	54:4,8,12
368:16	176:19 193:17	94:21 275:13	332:8 337:24	57:24 58:5,13
days 277:1,7	194:5 235:4	depends 82:13	describes 23:24	59:16,19 60:9

60:13 64:3	364:24	110:14 118:2,4	39:18 40:23	33:24 99:19
65:2,20 66:11	determined	119:25 120:21	41:20 42:2	100:3,15 112:6
70:23 71:2,6	217:18 219:1	121:8 136:14	47:10,11 50:19	114:25 115:4
71:10 73:9	determines	143:3 148:4	53:16 56:13	325:8
81:21 84:12,17	116:1 195:5	196:9 197:5	181:9,14,16,17	disagreeing
85:5,8,11,13	303:25	198:22 199:14	181:19,23	128:9
86:5,18 101:21	determining	203:25 209:20	182:8,10,17,20	disappearing
109:22 110:3	56:7 58:7 69:2	210:14 211:16	183:5,8 201:21	207:13
113:8 115:12	72:15 131:19	211:24 216:1	205:3,10	disciplines
116:4,6,23,25	139:17 263:20	220:22 241:21	206:10,17	110:14
118:15,18	267:1,21,25	242:2 243:12	207:8 209:12	disclosures
123:5,10,14	335:6	243:13,20	212:12 217:14	165:15 166:4
124:6,11 125:4	develop 348:8	245:12 259:12	218:9 219:24	discriminate
125:15 127:13	developed	261:9 267:16	229:13 235:6	319:2 324:9
129:6,11 130:1	132:12	271:4,16,17	236:8 237:13	325:4,11
131:14 132:15	development	274:20 282:21	238:18 239:5	discriminating
133:7 134:11	361:11	283:3,6 286:16	241:14,24	325:15
135:16,23	deviation 190:2	286:21 287:2,4	242:12,19	discrimination
136:7,22 137:5	deviations 94:21	288:9,22,24	243:19 256:19	84:5
137:21 138:4	devise 264:6	289:20 290:2	257:9 259:1	discuss 184:15
139:8 143:4	devised 265:4	300:2 301:5,7	360:18	318:20
154:3 167:21	dgeier@cprla...	301:10,13,15	dimension	discussed 15:7
168:22 171:16	2:12	301:17,18,21	201:20 244:13	98:10 260:4
171:20 182:11	diagnosis	304:2,4,9,14	271:5	267:15
182:21 183:9	187:25 188:4	304:15 305:11	dimensions 40:2	discusses 211:16
186:6 188:10	diagnostic	305:11 306:4	41:8,12,19	discussion
189:20 193:10	181:20 200:1	306:25,25	82:7 178:12	126:15 160:20
194:2 195:20	278:21 288:17	307:12,13,21	184:6 196:23	162:2 205:21
196:19,21	diagram 92:22	335:15 336:11	198:6 199:24	319:8 329:14
198:10,18	diameter 313:2	336:13 344:24	200:1 213:1	337:15,18
216:6 221:21	dichotomy	361:5,13	219:4 270:5	355:25
238:3 256:19	249:24	362:13,21	271:22 295:19	diseases 44:1
256:23 257:9	difference	differentiating	318:7 331:20	dispersion
258:5 259:1	248:13 277:6	206:19	diopside 190:20	275:16 278:15
264:24 265:21	277:10,12	differently	190:21	278:18,25
265:23 266:8	290:19	53:10 283:23	Diplomate 1:17	279:2,14,17
266:13,18	Differences 5:9	287:8	366:3,17	282:6 283:1,4
267:7 268:20	309:4	differing 163:19	DIRECT 9:23	283:12,16,20
269:1,22,25	different 49:8	164:6	direction 52:22	285:12,15,19
270:7 275:21	52:8,16 55:1	difficult 51:25	290:8,9	286:1,11,25
276:2 277:10	65:19 68:25	107:16 151:3	directions 40:3	287:16 288:3
295:8 297:8	69:14 70:8,11	152:7 182:5	41:14 201:12	289:12,16
305:9 316:21	70:23 71:1	188:18,18	271:11 289:2	dispersive 128:1
318:8 331:12	72:18 82:18	214:20 217:2	director 51:2	disproportion...
331:25 332:8	87:24 89:16	331:17	52:22	111:4
339:15 340:18	91:3,22 108:5	diffracted 39:20	disabled 142:11	dispute 224:23
342:19 353:8	108:9,11	diffraction 6:5	disagree 7:15	225:2

distance 200:7,9	136:9,13	159:20 160:21	61:5,25 69:11	driving 46:3
distances 235:1	137:17,25	161:18 165:17	70:5 88:15,20	drop 191:6
235:2	138:18 139:2,6	165:22 166:6,6	89:10 101:10	Drs 16:18 19:13
distinction	141:24 142:16	166:11 189:5	102:25 103:4	23:11 56:25
265:20 311:1	152:19 173:13	194:25 205:4	103:12,14	69:21 77:8
314:17 362:12	175:9,17 176:1	205:10 219:24	104:23 105:10	80:14 81:11
distinguish	176:15,21,23	228:1 229:1	107:18 108:12	89:15 98:1,4
47:17 146:22	176:25 179:11	231:3 232:1	111:3 128:7	100:8 113:14
152:8 213:25	180:10 189:4	235:21 236:9	129:23,23	139:11 142:10
214:21 215:17	194:17 201:22	237:1 238:9	130:12 143:14	156:20 158:20
215:25 217:3	218:9,12	239:6,10	153:6,16	159:16 160:7
325:19 331:17	223:19 226:7	241:15,24	158:11,12	160:17 198:17
distinguishing	227:8,17	242:12,20	160:21 162:22	205:6 217:7
295:16	228:18,21	243:19 249:10	165:8 166:3	239:25 258:10
distraction	233:16 235:6	336:9,17 341:9	167:12 170:2	264:10 270:12
312:11	260:3,9 262:20	341:10 342:4,5	171:19 179:6	270:21 297:21
distributed	279:20 284:3	352:13 353:16	180:22 191:3	313:5 321:16
249:17,22	286:9 290:15	356:15,25	200:5 201:21	328:25 335:23
distribution	300:2,9 303:11	357:2 358:13	205:21,21	340:1,9 341:6
13:8,8 190:1	305:14 315:7	doing 14:20	211:3 218:10	347:6 353:8,21
196:25 248:4	316:17 317:12	28:10 29:12	242:25 244:24	Duces 4:12
249:19 252:9	318:24 321:15	34:24 37:25	245:13,24	due 145:16
322:2,5	325:4 327:8	38:4 41:16	246:19 247:17	345:6
distributions	330:6 333:13	64:12 76:1	247:25 248:20	Duke 144:5
252:3	334:23 335:1,3	125:21 142:4	248:23 249:8	duly 9:18 366:5
DISTRICT 1:1	336:5 339:15	146:1 154:1,9	251:19 252:11	dust 49:3
1:1	340:2,11,15	171:15 209:10	252:15,22	Dyar 1:13 4:11
diverging 314:8	344:14 346:1	211:7 234:22	258:4 273:17	4:11,13,13,15
diverting 315:25	346:21 348:3	245:1 269:15	278:14 291:14	4:16,18,19,22
dividing 328:3	351:11,19	295:13 349:16	292:13 298:13	5:1,5,7,9,11,13
doc 358:7	352:24,25	367:8	310:25 322:8,8	5:13,14,16,18
doctor 43:10	353:3,5	dolomite 66:6	323:11 325:22	5:20,22 6:1,3,5
231:18 351:4	document's 66:3	doubt 111:8	330:15 331:10	6:7,8,11,13,15
363:13	documentation	312:11 345:5	331:11 342:11	8:11 9:17,25
doctors 146:1	165:2	346:13	355:4	14:25 15:4
document 1:6	documented	downside 65:9	draft 47:22	22:14,18,19
4:15 22:18,22	164:20	dozens 24:9	drafting 31:21	25:20 32:2
27:22 28:22	documents 7:17	358:15	drafts 31:17	60:24 61:5,5,6
35:12,15,19	15:13 17:1,25	Dr 8:11 16:24	drag 359:17	61:7,9,23
54:22,24 56:9	35:3,9,18	18:11,11 20:12	draw 147:11	66:18,19 67:13
56:12,15 57:9	54:25 56:6	20:21 21:2,2	265:19	67:16,17 68:12
63:6 67:21,22	57:2 61:14	23:5,14,23	drawn 198:8	68:24 88:11,18
73:11 90:6	64:8 66:14,16	24:8 30:23,24	201:23	88:18 89:11
93:2 103:10	69:17 73:13,17	31:2,7 32:10	drew 140:23	92:17 100:24
115:18 131:2	76:20,24 77:2	33:4,4,8,13,16	Drinker 2:19	101:2 139:20
132:4,4 133:21	82:19 93:17	33:21 34:3,17	9:3,7	143:25 144:3
134:15,17	105:3 126:13	34:25 35:3	Drive 2:22	147:8,19

148:20 152:20	124:18,21	260:16,18	266:15,20	ended 173:8
161:15 172:12	125:6,20,25	268:24 269:13	347:12 351:9	274:3
213:17 223:8	126:12,13	269:14,23	351:23 361:2,7	ends 312:19,24
236:5 256:14	130:9,10,16,24	effect 248:21	361:18	313:22 314:1,9
279:21 300:10	131:6,22,24	effects 44:9	electron-based	314:21 315:3,4
308:14 329:23	137:3,19 138:6	egg 42:17	361:12	Energy- 127:25
333:14 343:14	138:9,24	eggs 42:17	Electronic 4:15	energy-disper...
343:18 350:23	139:16 140:6	eight 153:19	electronically	38:25 39:3
351:4 357:20	140:10,12,15	either 17:20	25:19	138:19 145:3
357:23,25	140:19,20	18:1 19:8 33:8	electrons 39:19	145:12 155:6
363:22,23	141:3,7,17	44:6 49:10	209:10	engaged 123:4
364:1 366:5	142:1,5,19	58:1 65:3	elemental 39:6,8	169:14
368:12	143:1,6,10	69:18 86:18,20	116:23 145:1	engagement
	148:3 149:1,10	98:10 103:18	145:14	16:1 62:13
E	150:14 151:4,9	104:3,5 118:10	elements 84:19	67:6 122:5,10
E 2:1,1 3:14,14	151:14,25	119:7,17	84:22 124:23	enrolled 43:2
e-mail 25:13	154:13,16	123:17 135:18	elimination	ensure 174:5
earlier 35:6 89:1	155:16,20	142:16 150:24	137:11	enter 29:14
108:21 309:2	156:15 157:6	151:9 167:8,17	Ellis 3:6 9:9	entire 10:25
335:11 343:23	177:17 179:4	176:10 177:14	14:1 21:14	89:4 134:15
Early 5:3	179:13 190:17	185:13,15	28:10	136:6 166:22
earn 11:18	193:6 195:8,10	186:3 187:2	Elmo 92:24	180:15
Earth 166:23	197:7 200:20	196:2 218:3	126:24 284:24	entirely 307:15
easily 82:1	202:3 203:1,22	232:9 241:17	287:9 347:17	entities 53:12
152:14 193:5	207:1 218:6	248:9 253:16	355:7	98:12
238:25	260:5,16,17	254:17 262:15	elongation	entitled 22:18
East 174:23	261:4,11	291:10 297:24	279:5,8,9,13	75:17 144:4
Easter 42:17	263:13 264:12	313:6 314:21	280:19 283:24	147:7 281:22
easy 226:3	268:24 269:4	319:14 326:11	284:11 285:7	309:3 316:3
311:22	360:24,25	340:16 357:7	287:17 288:2	entity 11:14,24
eBay 104:12	361:6,20	electron 4:21,23	289:7	16:7 48:21
ED 138:24	EDX 157:20	39:13,18,25	else's 77:2	52:25 123:9,13
206:16 207:24	EDXA 38:24	47:11 50:17,18	emission 50:20	311:25
208:13 209:17	47:6 71:20	50:24 51:6	employed 23:11	entry 29:19
209:19 210:11	83:21,25 84:4	53:16,16 67:24	310:17 349:19	environment
210:13	84:11 116:22	68:20 116:19	employee	46:14 169:9
edge 286:7,21	117:9 120:19	117:3 118:9,17	311:15 366:11	Environmental
edition 93:5	124:5,17	120:18 124:15	366:12	47:21 68:1
editor 145:20	126:17 130:2	136:11 149:23	employees 13:11	109:22
EDS 38:24 47:6	130:16,24	178:9 186:3	20:22,22	Environments
71:20 72:2,20	131:6,15,22,24	196:2 206:10	173:12 310:16	5:10 309:5
83:21,24 84:3	137:3,19	206:17 207:7	employs 311:25	EPA 54:23
84:11,17	142:19 145:4	207:17 209:2	EMs 53:22	61:17 67:18
115:24 116:22	146:4,21	244:19 256:18	enable 327:2	93:24 128:11
117:9,21	154:13 155:16	257:3,8 258:25	encountered	128:17 173:19
120:19 123:22	195:8,10 197:7	259:16,19	109:15	243:24 310:24
124:5,6,9,17	206:21,24	260:17 262:18	endeavor 59:6	epidemic 45:8

310:15	113:13 161:3	209:21 210:15	4:15,17,18,20	6:19 60:24
epidemiologist	165:24 166:15	253:25 257:7	4:23 5:1,6,7,9	172:12 223:8
43:7	229:20 230:17	290:17,18	5:12,13,15,16	223:12 231:7
epithelial 163:7	232:11,13	291:4,12,22	5:19,21,23 6:1	exist 219:16
equal 319:19	258:3,8,21	292:2 302:15	6:4,6,7,9,12,13	existed 263:10
equipment	259:24 260:21	examining	6:15 14:25	existence 12:3
53:20	263:5,19 264:3	48:15,22 72:14	15:4 22:14,18	existing 157:7,9
equivalent	334:25 353:20	118:9 212:2	22:25 23:1	exists 113:5
226:22 303:14	evaluating	230:15 244:19	24:25 25:11,20	166:22 169:8
erionite 154:19	169:25 230:16	261:16	28:2 35:10,11	180:17 185:6
155:7,17,21	267:12 326:9	example 14:21	61:10 67:14,16	expect 164:18
156:11,14	evaluation	54:21 56:10	67:17 88:11,14	239:19 248:12
157:8,10,12,20	18:19	65:10 74:4	89:5 92:17,20	249:1 251:3
158:7,10	evening 16:5	107:6 119:21	92:21 100:24	expects 195:7
159:25 161:22	343:17	127:25 133:13	115:18 129:11	experience
161:24 162:12	eventually 22:4	136:2 140:11	139:4,20	208:18 213:23
162:24	277:19	143:8 146:13	143:25 147:19	215:16 294:7
Erionite-Asso...	evidence 98:2	150:7 168:22	148:20,23	294:12,19
5:16 153:10	100:9 112:13	176:16 179:25	150:1 152:20	296:3,13 359:9
154:25	146:16 158:20	183:21 184:8	152:23,24	359:20 360:9
errata 367:6,9	180:21 211:10	184:15 185:18	158:3 159:25	360:24 362:17
367:11,14	231:19 243:18	185:19 186:25	172:15,17,20	Experimental
368:7 369:1	evidenced 68:21	189:4 191:8	172:21,23	153:13
error 299:18	183:21,23	193:3 197:24	173:11 176:6	expert 4:13
errors 43:25	evolved 361:13	216:25 219:21	176:24 179:14	11:10,19 14:6
especially 174:1	exact 81:25 95:6	228:2 237:7	186:8 202:19	16:1 21:23
essential 337:7	204:1 205:17	250:11 259:11	206:5 224:6	22:8,19 24:25
established	exactly 13:18	262:25 263:2	225:4 226:16	25:3 28:10
221:10 289:6	15:19 21:25	278:9 292:24	226:17 231:9,9	30:22 38:7
297:11 318:5	73:14 74:10	338:19	236:4,4,5	43:13,23 44:12
335:10 353:14	87:21 104:15	examined 187:2	256:15 257:5	44:17 45:4
establishing	119:23 128:9	examples 135:2	279:21 281:19	48:14,19 62:23
110:6	151:11 154:8	237:7 292:25	282:4 284:20	66:21 73:20
estimate 298:14	241:25 251:17	293:3,6,9	288:21 289:8	89:8 213:19
298:22	264:1 275:13	311:8	291:7 303:21	256:18 257:3
estimates	286:5,7 313:18	excellence 359:2	308:16 309:22	281:14 284:8
305:23	327:4 361:4	excerpt 148:19	309:23 314:1,8	308:17 310:3,4
et 4:24 5:13,17	examination	355:5	319:21 326:17	332:21 334:7
93:14 136:15	9:23 152:9	exclusive 336:15	326:17,23	357:8,10 358:2
136:15 185:4	360:2 363:10	exclusively 76:9	329:23 330:3,3	expertise 294:2
198:3,4 199:2	366:5	excruciating	332:22 333:14	expires 368:17
199:2 220:17	EXAMINATI...	142:24	336:20 343:14	explain 39:16
220:17 292:25	4:4	excuse 23:1	343:21 350:23	244:9 274:19
299:10,10	examine 96:4	184:20 186:9	351:2,3,5	explained 54:25
evaluate 25:4	119:24 233:16	186:15 269:14	352:17	195:9 355:19
56:24 57:1	examined	288:21	exhibiting 78:21	explains 182:5
60:1 69:20	180:23 204:13	exhibit 4:11,13	Exhibits 4:9	201:10

explanation 228:15 249:24 340:17	facility 52:21 fact 45:7 58:13 69:10 70:5	232:17,24 235:17 237:25 312:10 341:2	226:21 276:4 291:5 297:25 313:17,25	fibres 4:20 fibrils 79:16 111:8,14
explicit 194:23 228:15	75:16 102:6,8 104:4 105:11	356:2 360:4 far 36:3 107:10	314:6,8 315:15 315:20 324:24	fibrosity 79:15 fibrous 173:15
explicitly 56:10 56:13 143:19 171:1 235:3	107:4,13 112:12 114:22 115:1,6,9	107:10 113:15 113:15 217:4 229:19 344:11	335:11,19 346:8,19 352:7 352:10,17	173:23 174:21 177:2,24 182:12,25
Exponent 311:16 312:7	118:22 137:8 142:9 149:21	farm 156:9 162:8 163:10	fibers 17:22 19:7 24:13	183:4,6 206:19 206:23 341:16
exposed 105:21	156:4 157:16	fast 277:17 363:20	43:24 49:3 54:5 78:23	341:24 342:13 342:20
exposures 174:22	171:24 172:7 178:18 182:5	fault 298:13 323:10	79:11,16 80:3 99:10 101:20	field 46:4 143:9 222:19 236:12
expressed 69:13 70:7 72:21	193:3 204:25 205:2,3 221:2	fax 1:23 featured 364:16	103:7 108:22 137:12,13,14 144:17 145:2	358:19 359:23 fields 110:25 figure 87:10
187:12 235:19 237:16 239:24	221:13 222:1 226:15 235:16	February 23:15 23:20 24:6	146:2 154:2,20 157:12 174:3	107:6,7 125:12 126:3 127:7
extended 134:17	238:13 243:11 248:19,23	28:19 35:23,25 36:4 88:17,25	176:19 178:15 184:24 188:14	128:13,25 131:8 137:5,19
extensive 126:15	251:14 255:20 262:3 269:6	106:8 173:21 federal 24:10	188:25 189:18 189:25 190:4	140:11,21 141:18 142:19
extensively 93:16	274:25 285:16 287:6 289:19	feel 149:24 228:18 239:25	193:15 194:8 203:18 204:13	144:24 145:23 146:4,6 147:1
extent 10:18 32:20 34:11	292:14 304:21 305:17 317:9	fellow 358:22 ferric 60:5	204:15,19 205:1 227:1,9	148:9,25 149:4 149:13 150:8
138:3 166:2 171:21 185:6	321:9 323:19 338:10 340:7	ferro-anthoph... 89:23 91:25 93:22	227:19 228:9 228:11 231:8	150:19 151:12 151:13,23 152:7 154:11
194:9 256:20 256:23 257:9	361:9 facts 252:3	ferro-anthoph... 254:4	233:8 263:21 264:25 269:17	154:12,12,17 155:4,24 156:3
259:1 263:14 279:12	faculty 45:25 46:1 52:14	ferrous 58:5 60:6	270:25 290:16 290:17 291:4	157:19,24 158:4 179:23
extinction 290:18,20,22	fail 214:2 216:11 367:17	fertilizer 122:23 fiber 79:6,7,9,19	291:12,15,24 292:3,14	185:2 186:9 247:9,12
extract 305:19	failed 240:1 fair 114:18	79:24 80:10,20 82:10 85:16	294:20,23 296:19,23	249:20,25 251:17 254:8
extraordinarily 141:6	253:4 254:3 fairly 110:22	86:6,20 145:15 150:7 155:7,21	297:17 310:9 312:19 313:2	254:13,14,18 254:19,21,22
extraordinary 142:7	124:9 fall 15:20 28:8	174:7 178:14 193:19 195:6	313:22 314:8 314:20 315:21	278:10,12 279:25 280:3
extreme 261:1	familiar 45:7 66:17 67:13	196:20 203:20 203:23 204:7	316:2 317:25 319:18,20	281:13 284:8 286:9 308:22
extremely 189:11 361:8	78:8 92:11 97:6 110:8	207:10,13,25 208:13 209:19	320:4,13,22 322:9,18,19	312:20 322:13 347:10 360:16
eye 340:13	129:24 147:6 180:25 181:1	209:20 210:13 210:14 212:6	324:19,22 336:10 337:3	figured 364:15
eyes 185:13	181:10 222:1			
F				
F 3:2 130:20 131:25 134:22 206:6,9 241:12				
face 239:10				

figures 139:25	110:12 111:1	240:4 242:23	259:15 263:8	86:5,14,19
140:7 148:2,8	112:5,16 113:2	243:4,8 244:16	276:20,25	193:16 337:16
154:15 245:21	113:17 114:14	246:10,12,20	277:2 294:10	337:25 338:7
file 225:25	114:24 115:10	246:23 249:5	299:24 322:8	340:1 341:4
files 226:7	119:1 120:12	250:20 251:13	342:12	347:7
financial 75:18	120:15 121:10	252:7 253:1,20	finding 154:19	flexible 78:23
75:25	121:18 122:2	256:2,11 258:1	272:13 323:23	79:12 193:15
financially	126:23 127:2	258:23 259:22	findings 253:23	194:8 335:13
366:13	132:19 133:2	261:6 262:8	finds 40:25	338:8,9,12
Finch 2:7 4:5,7	135:14 139:18	263:4,16	finished 42:25	flip 28:15
7:21 8:14,14	139:22 142:13	264:21 270:23	76:22 77:4	flipping 26:17
9:24 10:1,24	143:13,23	279:19,23	102:19 104:6,7	FLOM 1:14
11:8 14:23	144:2 147:5,17	282:12,16,19	105:12 123:18	floor 354:6
15:2 16:14	147:21 148:18	282:24 284:6	firm 2:3 14:1	361:16
19:14 22:12,16	148:22 152:18	284:16,20,23	21:14 28:10	Florham 2:22
25:10,18,24	152:22 154:10	285:5 286:13	187:25	fluorescence
26:8,11,15	155:3 157:18	293:17,20	firmly 110:24	50:19
27:2,5 30:4,15	159:3,5,11,18	294:1,18	first 9:18 13:13	FLW 1:5
31:11 32:6,7	160:11,18	296:16 298:5,8	15:15 17:6	focus 199:8
32:14 33:24	161:5,14	300:14,15	21:4,6 28:8	285:24 342:5
34:2,14 37:4	162:20 163:17	302:25 303:3	29:17 34:25	focuses 136:1
37:15,19 38:9	164:4,17 165:6	306:11,14	35:12 42:12,18	follow 16:23
38:16,21 41:4	166:20 167:10	308:5,12	45:20 61:22	55:6 56:2,21
44:24 45:13,19	168:18 170:1	310:13,23	66:3,19 68:10	64:3 65:1
46:20 55:19,23	170:12 171:13	311:12,16,19	68:14 101:6	69:11 70:6
57:16,19 60:17	172:14 173:6	311:23 312:6	103:17 111:21	86:18 108:12
61:1 62:20	175:3,6 176:3	312:16 315:1	117:8,9,10	115:16,22
63:15,22,24	176:12 177:15	318:15 323:17	141:14 145:7	134:8,11
68:9 71:15	179:2,12 180:6	328:1 330:1	146:15 149:8	268:19
72:11 74:2,12	181:3 182:9,23	332:12 333:12	206:22 212:10	follow-up 159:4
74:21 75:14	186:12 187:19	333:16 334:5	223:21 239:19	followed 103:15
76:12,18 77:24	188:13 190:3	335:4 339:4	247:10 256:22	108:13 258:4
78:14 81:1	192:2 195:4	341:22 342:9	280:4,24 281:7	264:11 298:22
82:15 83:18	199:6 202:11	343:4,7,16	281:18 321:6	325:9 342:19
84:1 85:3,20	206:3 208:3	344:13 347:18	345:3 359:10	353:7
86:3 87:13	213:6,15	347:21 348:6	359:16	following 69:6
88:13 91:1,14	214:24 215:13	348:11,19	five 57:17 91:18	69:25 150:17
92:19,23 93:1	216:12 217:10	350:9 351:1	102:16 141:23	318:19 321:4
93:7,19 94:7	219:13 220:1,3	352:1,14,20	206:14 221:5	follows 9:21
95:19 96:7,15	220:20 221:15	353:23 354:15	227:2 243:14	23:25 24:12
97:1,12,19	223:10,14,17	355:1,8,13,21	249:14,23,23	64:10 70:12
98:6,19 99:18	225:3 226:4,10	357:12,19	254:8 257:23	127:18 265:23
100:14 101:1	228:8 229:8	363:11 365:8	flaw 340:5	315:12
103:11 104:1	230:7 231:1,16	find 7:17 55:3	flawed 199:5	footnote 190:13
104:20 105:8	232:5 233:3,18	55:24 87:10	205:7	190:15 191:6
105:23 106:21	234:7,15,20	111:13 136:3	flexibility 79:17	192:24 301:1
109:1,10	236:3,7 239:8	181:24 202:7	80:6 85:16	326:8

footnotes 245:6	247:21 261:23	97:23 98:14	G 3:14	geologists
force 81:18,19	276:2,6 298:16	99:12 100:5	gamma 50:20	153:15,20,22
foregoing 366:7	299:20 301:4	103:8 104:9	garnet 149:2,18	geology 42:5,8
368:4	302:21 303:21	105:1,15	Geier 2:11 8:17	42:13,18,21,25
form 71:24	307:11 310:6	108:23 109:5	8:17 69:22	113:21 167:4,8
73:23 74:8	321:20 348:20	110:17 112:9	general 4:13	334:19 358:19
90:21 96:22	352:17 356:4	114:6 119:19	22:20 30:11	George 4:24
97:4,15 99:12	Foundation	120:23 135:11	39:4 97:6	67:18
112:9 146:7	168:25	143:17 146:7	164:12 198:12	Geostatistics
157:14 158:16	four 1:14 89:14	157:14 158:16	214:16 257:18	355:18
184:8,12,22,24	89:15 102:22	159:9 160:3,25	319:9,13	German 359:6
185:7,8,10	197:5 206:13	162:14 164:10	generalized	germane 305:20
187:1 270:9	220:6 240:17	164:24 166:9	198:13	getting 120:10
312:3 318:2	243:13 269:21	169:12 171:22	generally 23:24	163:12 347:18
368:6	350:2	173:3 176:7	37:22 103:13	GI 227:15
formal 229:6,9	Fourth 3:7	177:12 178:16	109:3 111:7	Gilbert 359:3
formed 12:5	frag 297:24	180:3 182:2	121:3 125:10	give 80:15 98:25
164:13 165:18	fragment	187:7 188:8	184:14 188:21	102:1 107:8
former 20:22	178:15 185:22	189:22 194:21	189:16 196:4	124:23 141:24
forms 360:19	292:9 293:15	202:5 205:23	201:3 222:23	165:4 197:11
formula 90:8	293:24 298:2	219:19 226:9	259:5 271:10	219:10,15
95:7	316:23 318:1	227:23 242:16	276:17 316:8	245:5 311:8
formulas 90:7	335:8,8	250:1 251:24	318:18	326:10 327:15
forth 25:6 28:2	fragments	263:25 270:9	generate 125:3	327:17 336:11
55:4,25 56:19	177:25 291:23	310:22 311:3	generated 126:3	336:14 345:19
57:7 62:15	292:2,6,11,15	318:2 341:18	genetic 43:24	346:2 350:16
64:18 86:16	292:16 293:9	342:1 344:10	gentleman 20:8	given 34:24
353:10 355:24	293:13 294:6	347:24 348:9	geo-analytical	35:20 71:22
366:9	310:8	348:15	195:11	78:18 79:1,9
found 44:13,18	frame 249:4	full 41:11	Geochemical	80:14 84:9,13
45:1 58:21	frequently	269:14	358:23	90:24 91:12
78:4 89:17	277:16	full-time 53:21	geochemistry	94:4 95:17
94:9 96:19	front 15:4 26:19	349:13	42:10,11 43:5	99:22 110:23
97:3,21 98:9	61:8 152:24	fundamental	geographic	111:25 131:10
99:25 100:4,18	172:18 288:1	222:7 333:8	168:5,5	159:21 169:4
112:7,15	343:21	361:4	geographical	180:14 184:25
140:13 144:17	Frost 2:21 9:3,3	fundamentally	252:20	185:5 189:11
146:3 154:2	45:10,16 71:24	199:5	geologic 308:3	205:2,4 235:5
157:12 165:12	73:23 74:8,18	funded 168:24	geological	235:8 236:13
166:23 168:8	76:11 77:20	funds 11:18	333:18,23,25	246:19 247:16
168:21 169:5,9	78:6 80:21	further 73:14	334:16 336:23	248:2 267:17
179:22 185:21	82:11 83:1,23	157:3 165:13	358:24 359:4	272:6 278:10
187:2 190:22	84:15 85:18	166:12 264:19	geologically	334:23 340:6
191:15,16,21	87:7 88:8	363:8 366:7,10	164:13	340:24 346:13
192:4,11	90:21 91:8	future 42:19	geologist 112:25	350:18 368:5
226:24 231:8	94:2 96:2,12		113:18 114:13	gives 141:22
231:20 241:6	96:22 97:4,15		167:25	147:12 169:9
		G		

209:12 262:13 292:25 293:3,6 293:9 324:21 giving 16:22 233:20 234:1 glass 121:4 274:22 290:7 go 27:17 51:13 54:18 57:16 64:13 73:4 86:22 126:7 142:8 169:7 185:1 189:1 191:3 192:17 223:20 231:15 238:5 242:10 245:7 253:6 280:23 295:14 303:18 317:18 321:7 326:20 328:13 339:24 340:17 343:8 goal 56:23 69:19 96:3,5 101:21 139:11 166:12 166:14 261:21 347:4 goes 133:11 142:24 151:16 186:22 193:21 208:6 212:18 going 10:16 15:12 26:12 30:9 31:4,25 32:3,3 33:20 33:22 34:9 36:24 37:7 46:17 47:5 50:10 57:13 60:20 68:12 89:3,4 112:3 121:6 153:17 207:7,20 208:24 209:7 213:3 224:4,5 228:20 229:19 235:15 250:19	264:16 268:6 276:25 281:7 306:8 343:20 347:17 348:17 gold 145:16 282:11,13,17 361:1 Golkow 1:22 3:15 8:2 goniometer 196:12,13 207:10,14 209:3 211:4 212:4 244:18 good 9:25 60:18 121:19 143:8 158:24 161:6 161:15 165:5 171:7 213:7,16 256:3 277:22 278:7 307:22 307:23 308:13 334:4 343:17 360:14 Gouverneur 44:19 310:6,6 310:16,18 government 57:2,9 350:20 352:13 government's 334:18 governmental 48:21 93:25 95:11 123:13 Grace 74:4 122:17 grade 257:15 graduate 52:14 357:21,22 361:10 graduate-level 167:13 graduated 42:20 42:24 graduates' 360:6	graduation 43:3 grain 119:24 151:4 219:5 271:22 284:22 286:4 289:1 290:23 301:25 305:17 307:16 307:19,21 grains 116:4 271:17 288:24 290:13 299:1,8 grant 169:4 350:19 grants 350:14 graph 142:19 245:16 252:2 graphic 251:16 graphical 246:18 255:4,6 graphics 142:19 gravimetric 107:23,24 gravimetry 65:25 gravities 107:8 great 107:15 173:25 174:10 greater 217:17 322:15 323:21 329:16 grid 118:1 121:5 196:6 208:7,8 grids 196:7 ground 112:21 164:22 170:24 361:16 grounded 110:24 grounds 10:17 30:10 32:1 33:21 34:11 36:25 37:8 group 94:25 122:20 362:14 groups 257:7,11 259:3 312:18 313:21	Growth 6:9 grunerite 79:3 89:24 90:12 92:1 93:23 140:17 guarantees 302:1 guess 137:23 235:15 275:9 288:4 guessing 126:8 guidance 317:5 317:10 318:25 321:5 323:3 324:9,21 325:3 325:11 guideline 69:11 70:6 guidelines 82:14 336:11 Gunther 5:10 20:9 33:13,16 33:21 45:21 59:8 73:20 76:7 139:19,24 143:14 147:9 152:19 153:4 162:22 167:12 293:2 308:23 309:9 310:2,25 355:4 Gunther's 20:12 150:8 309:3 <hr/> H <hr/> H 3:14 habit 6:9 78:22 110:5 318:18 halfway 145:7 Hamm 88:6 Hammondsville 88:5 174:25 175:4 hand 25:25 126:19 184:19 188:20 207:11 297:4 346:1	352:23 354:14 handed 216:5 273:10 351:19 handful 215:3 handy 90:6 226:17 hang 87:9 309:11 happen 52:1 251:11 254:21 255:23 283:9 356:2 happening 75:7 75:9 286:3 happens 199:25 286:4,6 329:15 329:18 happy 80:15 86:24 126:20 162:16 220:19 242:9 334:25 hard 25:11 180:14 212:21 264:7 349:15 349:17 350:16 Harper 185:4,6 293:5 Harrison 3:12 8:19,19 Hawthorne 93:14 haystack 276:24 hazardous 44:9 HC 225:8,16 227:15,22 head 46:22 205:18 311:21 Health 109:23 341:14,16 heard 177:13 221:16 222:17 224:18 312:7 312:14 hearing 4:14 22:20 189:15 held 1:13 8:7 Helmholtz
---	---	--	--	--

359:6	242:4,8 285:22	IARC 91:17	47:6,11 72:1,2	360:12
Henry 3:14 8:1	honored 358:21	98:12,20 99:2	72:25 128:19	images 32:18,22
hereinbefore	hope 330:4	99:8 108:20	129:18 137:12	118:10 141:1
366:9	Hopkins 20:21	109:2,8 341:23	138:11 146:14	150:8 157:6
Herrington 2:15	horizontally	342:4	146:22 149:17	188:15 235:20
9:2	194:19	IC 152:19	151:19 174:15	236:1,19 237:4
Hess 281:2	host 174:18	Idaho 149:2,18	184:14 198:1,3	237:5,6,11,19
hexagonal 207:9	hour 15:22	idea 96:24 97:6	201:13,25	278:16 283:4
209:4	29:20 57:13	99:5 156:21	210:22 212:23	286:15,23
hide 276:23	112:3 213:4	180:5,9 235:12	216:8 222:4	287:12 288:20
high 30:12 37:1	306:9	241:9 338:2	241:13,17	291:22 292:1
78:23 79:12,16	hours 29:19,19	ideal 116:7	245:14 257:4	292:21 294:10
133:16 193:16	29:24,25 30:18	ideally 115:23	260:6 261:3	296:4,10
194:8 195:11	34:21,24 36:12	identical 79:14	270:14,25	308:22 309:1
197:11 226:25	36:14 276:5	284:7	271:19 272:2	309:20,21
328:21 335:13	277:11 350:15	identification	273:6,11	326:3,22 328:6
336:10	365:2,6	15:1 22:15	277:17 292:9	328:9 331:5,17
higher 150:12	human 43:14	25:21 47:23	297:16 298:3	imagine 85:23
276:20 315:21	144:17 146:3	49:10,15,20,24	317:23 333:24	201:8
320:6,14,23	154:3	53:25 60:25	364:6,10,14,19	imaging 155:12
322:10,21	hundred 27:21	88:12 92:18	365:4	Imerys 5:19,19
324:7 325:1	217:1,11,20	100:25 132:7	identifying	5:21,21 14:21
329:7,12	219:16 263:18	133:23 134:4	54:16 65:12	103:16,18
highly 109:20,23	296:20 308:4	139:21 144:1	194:10 264:14	122:8,8,9
109:24 149:21	hundred-plus	147:20 148:21	293:12 294:12	165:18 166:6
248:3	27:21	152:21 172:13	identity 151:20	173:9
hired 14:12	hundreds 51:24	187:10 201:23	Illinois 140:14	Imerys' 5:2
77:21 123:8,12	292:5,10,16	202:25 203:10	image 40:17,23	immediately
168:13,13,20	294:6 297:6	209:18 210:12	119:11 150:12	35:18 144:10
169:21 170:2	358:13	223:9 236:6	177:17 178:2	321:4
historical 5:1,2	hunt 42:17	244:14 245:17	185:2,5,13	imperative
104:24 105:4	Hurlbut 5:6	265:13 279:22	188:1,3,11	367:13
233:21	93:5 201:15	295:21 315:15	211:9,14 212:5	implied 324:12
history 42:6,21	Hurlbut's 92:12	329:24 333:15	235:1 262:17	implies 102:6
43:1	hydrogen 348:8	343:15 350:24	274:23 278:9	138:14 145:9
HKL 242:21	hydrous 173:17	identified 86:12	278:13,19,25	237:16 307:23
hold 43:12,22	hypothesis	103:6 128:18	279:6,8,9,11	imply 138:5
holder 208:1,5	252:6	174:22 204:20	279:13 280:6	important 41:22
Holly 359:4	hypothetical	205:6 215:4	282:5,6 283:13	75:23 76:6
Holyoke 11:25	118:11,13	220:23 227:19	283:16,20,21	78:1,8 125:22
21:10 51:1	168:12 258:19	242:3 254:3,8	283:24 285:7	171:18 239:2
52:6,16,19,20	261:1 263:9	255:8 294:5	285:11,15,19	314:17
53:13 349:6	hypotheticals	321:15 331:10	285:25 286:1	impossible
home 12:22,24	250:3	identifier 225:9	286:11 287:8	130:7,10 178:1
honest 76:5	I	identifies 70:19	287:10,23	198:14 237:18
honestly 103:21	i.e 215:15	91:17 198:22	288:2,4 289:7	237:20 238:11
126:12 163:23		identify 46:11	318:12 331:18	318:13

improperly 323:22	increasing 320:2 320:8,9 321:2 321:2	industry 133:18 308:2	148:14	intensify 287:22 288:15
impurities 65:14 270:14	indefensible 241:13	inference 140:21	inquiries 99:17	intent 149:11
impurity 62:10 277:3	independent 109:8 149:22 156:5,22 158:8 158:10,14 215:10 297:3	inferring 94:12	inserted 278:20	intentionally 135:8
inch 82:4 343:24 344:6,25 345:14 346:10	independently 131:12 240:3	inform 269:6	inspect 146:12	interaction 359:24
Incidentally 306:7	index 4:1 108:8 151:17 196:22 197:16 219:6 271:10,14,16 275:18 279:12 291:6,7	information 17:13 37:22,24 37:25 38:3 84:11 85:13 97:25 99:21 139:8 152:10 152:12 156:25 159:21 161:24 162:10,23 168:4 171:17 171:18 175:17 176:1,5,15 180:12 223:6 229:14 230:2,6 233:13 236:25 237:3 239:4,21 245:24 253:12 253:15 254:12 255:16,21 258:15,20 259:23 260:8 261:5,12,25 263:11,13,14 271:4,5 273:1 273:22 281:4 291:10 298:17 304:20 305:5 305:19 306:15 322:12 325:25 336:17 343:2 349:8 353:15	inspected 274:4	interactions 360:2
include 20:20 90:11 93:10 111:24 134:24 143:20 146:5 148:11 149:3,7 149:15,25 152:4,17 191:8 201:14 211:9 328:6 336:17	indicate 108:4 181:20 230:21 254:22 298:17 338:11	infer 171:18 175:17 176:1,5,15 180:12 223:6 229:14 230:2,6 233:13 236:25 237:3 239:4,21 245:24 253:12 253:15 254:12 255:16,21 258:15,20 259:23 260:8 261:5,12,25 263:11,13,14 271:4,5 273:1 273:22 281:4 291:10 298:17 304:20 305:5 305:19 306:15 322:12 325:25 336:17 343:2 349:8 353:15	inspection 215:24 259:11 359:21	interest 21:24 75:3,19,25 169:23
included 35:9 59:6 102:23 180:13 192:25 204:18 225:9 250:7 255:7 292:21 328:17 357:8	indicated 17:25 150:14 326:2 338:10	ingest 44:7	instances 16:5 66:9 272:1	interested 22:2 42:13 366:13
includes 20:2 52:16 66:4 89:19,22 91:24 194:6 240:6 335:12	indicates 129:4 246:25	ingot 346:18	Institute 84:25 349:20	interesting 354:15
including 69:13 70:8 79:13 120:6 286:9 328:15 359:2	indicating 349:9	ingredient 170:19	institutions 52:8 53:9	Interestingly 300:8
income 12:1 13:8 350:13	indication 42:18 144:13 176:17 285:11	ingot 346:18	instruction 67:9	interests 17:5
inconclusive 65:17	indicative 276:3	ingot 346:18	INSTRUCTI... 367:1	intermixed 92:7
inconsistency 272:9,12	indices 150:25	ingot 346:18	instructs 208:12	internal 17:24 69:16 76:20
inconsistent 206:1	Indirect-trans... 4:20	ingot 346:18	instrument 130:18 143:12 235:3,7	international 61:15,19 62:3 93:12 95:11 98:23 99:3 153:12 329:5 359:1
incorrect 176:6 285:18 300:23	indistinguishable... 151:15 218:6	ingot 346:18	instrumentation 265:3	interoffice 5:18 175:19
increase 279:3	individual 73:18 135:3 145:2 187:25 188:1,3 188:10 196:24 198:15 205:1 211:21 219:9 234:24 318:11 345:7	ingot 346:18	insufficient 145:24 176:14	interpret 236:19 283:23 338:5
	individuals 135:4	ingot 346:18	insulation 132:21 133:5 133:10,13 134:9	interpretation 307:9 318:23
		input 148:17,17	integrated 304:3	intimately 360:4
		inputting	intend 34:15 332:24	introduce 8:13
			intended 134:18 134:20 317:5,6 317:10,15 318:25 319:1 321:5 323:2 324:8 325:10 336:14	introduced 10:2 133:12
			intense 278:21	introductory 356:5
				investigated 168:8 195:3
				investigation 69:20 165:23
				invoice 28:18 29:17 34:21

35:21,23,24 invoices 16:4 28:16,20 30:19 37:20 38:11 involve 246:22 involved 144:12 229:25 246:17 359:23 361:10 361:15 involving 74:5 358:15 iPad 25:16 iron 60:4,5,5,6,6 60:10,13 90:11 155:10 173:17 181:5 192:25 218:4 346:17 346:18 347:2 iron-bearing 218:5 iron-rich 89:22 91:25 93:22 94:8 irrelevant 118:2 273:25 274:2 286:12 328:20 ISO 4:16,18,19 40:9 49:9,14 49:19,23 54:23 55:4,25 56:14 56:19 57:7 61:15,16,23 62:15,25 63:18 64:1,1,4,6,18 64:24,24,25,25 65:18 66:8,9 66:18,20 67:6 73:13 79:13 86:15,16 107:23 108:13 126:1,13,14 127:4 128:10 128:16,22 129:3 130:13 131:19 133:4 133:21 134:16 142:16 182:4	189:5 205:19 206:5,16 211:16 212:1 272:4,11 298:20,24 299:4,9,11,15 300:2,5,7,23 302:4,5,21 303:12 306:21 307:9,17 312:25 313:9 314:7,25 319:12,13 320:23 322:24 324:4,18 329:14 336:4,4 336:18 issue 34:25 105:10 341:8 issues 176:21 issuing 310:4 Italian 241:7 249:16 Italian-sourced 220:24 255:14 Italy 17:20 19:8 87:17 170:5,13 170:14 192:17 192:20 214:10 248:9 251:21 251:22 item 260:20 <hr/> J <hr/> J&J 6:15 9:1 33:22 226:11 J3 272:20,22 273:19 278:3 J4 233:6 J4-1 232:18 J41 232:18 Jack 2:21 9:3 jack.frost@db... 2:21 January 35:22 35:23 88:21 89:5	Jayme 254:10 Jersey 1:1 2:13 2:22 JNJL61_0000... 5:23 JNJL61_0000... 5:24 JNJMX68_00... 6:2 JNJMX68_00... 6:2 JNJNL61_000... 6:16 JNJNL61_000... 6:17 JNJTACL000... 6:4 job 19:11 23:10 170:18 341:7 349:13 John 20:21 Johnson 1:3,3 2:23,24 5:1 9:4 9:5 14:12,12 14:15,15,15,15 14:16,17 15:16 15:17 16:16,16 17:25,25 18:7 20:5,5,17,17 20:22,23 21:5 21:5 27:3,3 28:11,11,25,25 29:14 31:15,15 32:8,9,15,16 33:10 36:21,21 44:13,14 62:13 62:13,23,23 63:20,20 66:22 66:22 67:7,7 69:16,16 76:20 76:20 77:3,15 77:15 87:5,5 87:15,15,24,24 96:20,20 100:16,17 103:5,5,6,6,16 103:16,18,18	104:6,6,7,7,23 104:23,24,25 105:12,12,13 105:13 106:6,6 122:4,4,10,11 159:19,20 160:20,21 164:19,19 165:17,17 166:5,6,24,24 172:25,25 174:12,12 190:23,23 191:22,22 192:13,13,19 192:20 214:10 214:11 216:16 216:16,22,22 224:21,21 226:7,8 231:5 231:5 232:7,7 232:14,14 233:21 234:3,3 241:8,8 258:2 258:3,12,13 263:19,19 349:11,12 350:1,1 351:5 351:5 352:6,16 353:10,17,17 354:2,3 Johnson's 5:1 17:16 18:7 19:1,9 29:14 33:10 44:13,14 69:18 77:3 113:6,7 220:24 233:21 352:7 352:16 353:11 joule 81:14 joules 344:4 journal 50:6 75:1 101:17 109:13,16,17 109:19,20 110:4 140:4,6 145:22 147:3	153:12,12 332:25 333:5 362:3 journals 110:9 333:7 JR 2:21 judge 7:23 178:1 judges 24:10 judgment 40:24 41:25 172:9,9 230:3 293:15 294:3 314:3 judgments 84:20 318:14 Julie 5:21 177:7 177:14 July 6:1 61:17 223:25 226:19 258:15 259:6 justified 17:14 <hr/> K <hr/> K 235:11 236:12 236:12,12,22 239:11,19 Keaton 253:23 254:3,11 Keaton's 253:25 keep 7:11,18 38:19 46:9 226:17 281:7 keeping 358:13 keeps 357:19 kept 53:20 key 295:15 kind 17:4 37:22 39:17 69:3 118:2 141:13 141:16 145:24 159:2,21 169:16 176:17 178:23 254:3 258:18 261:1 263:9 269:23 270:3 275:6,13 277:2 283:6 287:24 295:5
---	---	--	--	---

296:6,6	192:3,10,15,18	194:23 202:16	laid 220:7	326:24 327:2
kindly 27:3	194:18 198:7	221:1,6 226:12	large 133:13	328:3
kinds 50:17	201:12 214:13	227:25 232:16	175:23 285:13	lengths 313:3
52:16 146:17	215:8,11,20	234:4 238:24	340:13	lengthwise
271:4 274:20	217:4 220:21	312:5	larger 111:5	193:15 194:7
318:13	221:11,24	knowledgeable	laser-induced	lens 274:16
Klein 5:5 92:11	223:1 229:18	107:12	50:20	275:2,2,14,16
93:6 201:15	230:19 236:24	known 60:14	late 7:10	279:2
knew 58:8	241:9 242:1	131:13 214:2	lattice 199:25	Lepoy 328:15
156:14 297:2	243:11 244:12	215:18 304:8	law 2:3 14:1	let's 25:10 35:8
know 19:16 36:9	246:8 249:7	knows 244:7	28:10 354:16	38:22 54:18
36:17 53:3,5,6	251:8,11 252:2	Krekeler 18:13	lawful 9:18	64:24 73:5
56:23 58:12	252:9,15		lawyer 11:16	78:19 88:14
59:11 61:21	253:11 254:6	L	21:11,13,17	92:20 135:25
67:10 68:20	255:17,22,24	L 334:13	28:9 61:9	141:14 151:12
75:17,22,24	259:8,13,17	lab 23:25 24:19	73:25 74:10,20	169:4 172:15
81:8,14 82:18	260:10,13	50:23,25 51:3	74:23 354:2	203:15 204:23
86:22 87:1,8	262:24 270:13	103:14 129:23	LAWYER'S	212:8 217:25
89:6,12 90:17	272:21 274:15	211:3 273:17	370:1	218:15,17
90:22 91:4,11	276:7 277:15	278:3,4 291:14	lawyers 16:16	242:11 245:7
93:13,21 95:9	279:5 285:2	label 215:23	31:14 32:8,15	269:3 280:23
95:21 96:18	287:13 289:4	281:16 348:1	33:10	289:2,6 291:18
97:2,9,10	292:7 293:18	labeled 190:18	lay 64:1,25 65:5	292:22 295:14
104:16 105:18	297:18 305:5	213:21 227:9	layer 207:13	298:9 299:11
105:22 109:19	312:25 314:2	283:8,10	layers 181:19	299:23,24
112:23 114:10	317:23 322:11	289:18	200:9	300:6 308:5
114:11,15	334:22 335:17	labels 166:5	layman's 278:22	309:11 317:8
115:5 127:15	340:10 341:20	laboratories	lays 63:1 65:19	318:3 321:7
127:19 129:7	341:23 344:12	47:25 53:7	68:24 80:18	325:16 330:2
129:17 131:21	345:25 349:8	221:17 222:18	lead 43:25 59:8	333:17 335:21
132:13,21,25	350:12 352:25	laboratory 23:5	153:17	338:2,20 347:3
133:4,5 134:10	353:2 354:7,24	48:3,3 51:21	learn 261:17	364:13
138:14 146:13	363:14,15	52:4,11,15,18	leave 37:15	letter 6:1,4
149:18 157:15	knowing 169:23	53:22 116:9	led 16:8 162:11	38:18 224:9
158:7,9,11,12	172:7 229:23	186:1 207:22	Lee 122:20	225:16 226:18
159:19 160:14	269:5	221:20 222:21	330:8,12	229:15 239:20
162:15 163:24	knowledge 54:2	222:25 252:12	Lee's 311:1	letter's 225:18
163:25 164:2	68:8 81:25	275:1,23 276:1	left 119:13	letters 225:8,20
164:12,13	98:16 99:25	276:4 304:23	278:18 283:15	level 30:12 37:1
165:1 167:7,18	100:22 109:8	315:14 364:23	334:24	55:11,14 68:25
169:17 170:7	111:22 112:11	365:2	legal 29:8	69:1,1,12 70:7
171:19,25	114:8,21	labs 53:23	Leigh 2:3 8:21	70:12 129:10
172:2 175:23	135:13 156:21	272:24	leigh.odell@B...	135:25 136:2
176:22 177:7,9	160:13 165:3	lack 32:24 39:24	2:4	136:12,18,18
180:10 189:16	165:19 167:3	41:19 60:10	length 85:17	136:21 137:8,9
190:7,21,25	173:5,10	lacking 238:23	143:2 184:2	137:10,13
191:14,20,24	175:11 183:1	239:21,23	187:13 286:5	197:11 203:16

204:14,14,17	280:24 316:6	62:17 63:4	34:19,25 35:3	329:20 335:23
204:18	318:20 337:7	75:11 82:24	56:25 68:5	340:1,5,9
levels 137:1	literally 282:9	95:25 98:13	69:11,21 70:5	341:6 342:11
182:7	297:6 300:19	100:6 106:17	77:4,8,19,22	347:6 353:8,21
LHG 1:5	364:12	112:22 113:10	78:1 80:14	358:1
LIABILITY 1:5	literature 79:9	114:19 118:20	81:11 87:20	Longo's 31:2,7
Libby 45:1,9	80:7,18 82:3	132:2 142:21	89:15 98:1,4	32:10 33:4
58:22 59:15	83:4 98:11	154:5,23	100:8 101:10	61:25 88:15,20
life 11:1 295:4	119:15 140:3	158:17 167:1	103:12,14	89:10 105:10
light 47:16 63:8	142:17 144:7	170:25 175:15	104:23 108:12	107:18 129:23
65:11 102:7	144:16 169:7	182:15 189:23	112:12 113:14	165:8 205:21
116:3 117:14	169:24 201:4	212:7 215:6	125:2 128:7	211:3 218:10
117:18 118:24	293:14 294:9	219:18 220:8	129:23 130:12	242:25 244:24
120:4,20 121:3	352:12 358:12	221:8 232:25	139:11 142:10	245:24 246:8
126:10 178:24	litigation 1:5,22	233:11 238:21	156:20 158:11	246:13,14
196:18 197:9	3:15 8:3,9 14:6	239:15 248:17	158:20 159:12	247:17 252:11
266:9 271:3,23	14:14 20:5,13	251:6 285:21	159:16 160:7	272:24 273:17
273:12 274:17	35:6 73:21	294:14 310:19	160:17,21	278:14 291:14
288:15 290:8	74:14,16 76:10	314:22	165:25 166:3	292:13 331:10
291:19 294:21	103:2 106:7	log 110:2	170:2 171:19	331:11
294:23 296:5,6	little 21:24 26:2	logical 304:25	180:22 190:18	look 22:21 28:5
318:17 359:14	41:17 57:15	long 12:2 79:20	191:3 194:24	33:2 34:6 35:8
363:5	70:10 91:2,21	80:10 162:16	197:22 198:17	41:17 51:13
likelihood	146:11 154:6	186:7 188:3	200:5 201:21	59:12 78:10
276:20	193:8 212:9	273:12,13	204:24 205:6	90:8 92:2,2
limitation	213:3 218:1	276:8,13	205:10 213:24	98:24 102:2
323:25	240:19 294:7	277:18 331:25	214:18 217:7	119:21 121:2
limitations	294:11,19	335:20 345:25	232:12 237:25	126:20 130:8
56:14	296:3 304:19	349:17	239:25 241:14	130:10 135:25
limited 13:7	306:8 365:1,5	longer 235:22	245:13 246:19	146:9,19 154:7
limits 272:4	Lizzy 3:12 8:19	315:21 319:18	246:25 247:25	162:4 165:11
line 32:5 33:23	14:23 22:12	320:4,13,22	248:20,23	165:22 178:11
163:6 286:6	293:17	322:9,18,20	249:8 251:19	182:4 186:16
369:3 370:3	LLC 2:7 3:9,9	323:12 324:20	252:15,22	189:2 196:8,8
lines 207:13	6:7 11:13,14	324:22,25	258:4,10	200:24 203:15
liquid 108:8	12:8 13:3	326:8 331:25	264:10 270:12	207:3 209:2
list 20:2 35:8	29:12,13,15	longest 291:5,6	270:21 272:1	211:4,15,20
46:17 51:5	LLP 1:14 2:15	321:25	272:19 274:5	212:13 240:11
90:11 192:25	2:19 3:1,6	longitudinally	278:4 297:21	241:23 242:5,9
239:7 337:13	localities 214:15	194:20	298:13 304:20	242:10 243:10
357:9	locating 203:17	Longo 5:4 16:18	305:16,22	244:11,18
listed 46:10	location 255:24	16:24 18:11,20	313:5 321:11	250:4 251:17
165:16 194:16	locations 255:8	19:13 21:2	321:16,20	259:9 260:16
202:12 281:23	255:22	23:5,11,14,23	322:8,14	269:17 271:11
355:19	Locke 3:1 8:24	24:8 30:23	323:11 325:17	271:16 276:12
lists 166:5	9:11,11 19:10	31:3,5 32:19	325:18,22	280:2,8 284:23
194:16 249:7	44:21 45:11	32:20,25 33:8	328:16,25	285:3 286:15

286:21 290:1,3	looks 124:6	142:20 152:25	35:24 36:8	57:25 59:14
292:7 293:7,10	149:11 158:8	159:8 176:6	250:23 251:20	65:4 71:22
294:10 295:5	177:24 178:14	229:12 281:15	mark 23:17	75:4 78:5,5
297:23 300:3,6	179:24 186:8	281:19 363:24	25:10 88:14	81:22 116:24
309:12 321:8	224:14 226:14	machine 225:22	89:4 92:20	130:3 131:20
328:13 331:13	241:16 285:2	macroscopic	172:15 236:3	131:23 133:7
340:18 345:9	299:17 339:18	297:4	330:2 333:17	134:9,12 136:8
359:16,17	Los 52:11	madam 55:20	marked 14:25	136:23 137:6
looked 17:7,12	lost 289:3	magnesium	15:4 22:14,17	137:20 150:4
33:1 80:2	lot 167:16	173:17 191:11	25:20 60:25	164:21 169:19
118:19 124:11	176:20 233:13	218:4,5	61:8 66:18	170:4 171:20
130:9 153:7	250:2,15 251:4	magnification	88:11 89:11	172:3,6,8
160:6 163:5	251:18 262:14	150:12	92:17 100:24	177:3,24,24
205:14 243:15	309:6 361:10	magnitude	139:20 143:25	179:8,16,19
243:17,20	lots 352:11	174:16 339:10	147:19 148:20	181:25 182:1
292:5,10	Louis 3:8	maintained	152:20 172:12	185:21 193:11
294:22 296:11	lovely 284:21	104:25	206:5 223:9,11	194:2 196:22
296:14,18,24	low 262:25	majority 248:10	236:5 279:21	197:5,10 202:4
297:13 309:2	339:9,11	319:18	309:22 329:23	225:10 243:24
321:11 326:16	low-grade 97:9	makeup 95:6	333:14 343:14	248:5,16 273:7
340:14	114:10,23	124:19	343:21 350:23	273:17,24
looking 35:10	lower 319:20	making 143:3	354:23	274:1,8 276:18
40:15 56:16	329:21 346:17	193:24 198:23	market 102:23	277:12 286:16
82:14 89:7	lunch 158:25	238:11 244:20	marketed	307:11 344:8,9
95:3 111:16	161:6,16,19	245:2	104:19	345:24 346:8
121:4 130:2,3	163:3	malignant 5:16	marketers 174:2	350:21
133:8 137:3	lunchtime 159:1	153:10 155:1	MARKETING	materials 4:17
145:6 150:3,5	Luzenac 174:12	163:7	1:4	4:18 7:5 19:7
166:12 169:11	177:10,14	man 348:24	markets 225:7	24:13 25:14
189:3 197:12	180:5	management	Mars 168:21	33:5 44:13
203:7 204:2	<hr/> M <hr/>	174:11	348:21	47:6,12,18
207:16 209:1	M 2:11,20 4:11	manager 53:22	Marte 3:14 8:2	48:4,9 49:2
210:4 211:1	4:13 22:19	mandate 249:12	MAS 6:7 246:25	51:7 54:4,8,12
214:17 215:23	366:5 368:12	264:3 353:19	Mass 12:13	58:21 62:5
245:1 255:1	M68233-001 6:6	353:20	Massachusetts	63:3 64:5 66:2
260:19 262:17	M68233-002 6:6	manner 179:1	12:7,8 29:10	88:20 90:18
273:25 275:21	M69680-015BL	Manual 5:5	52:13	91:5 107:25
276:1,17,19,22	6:7 280:25	92:12	masses 312:20	133:15,23,24
277:4,11,13	281:11,11	manufactured	313:23	134:1,3 135:4
280:4 281:13	M69680-015B...	132:8 290:7	match 252:2	140:7 154:13
282:10,12,16	282:25	manufacturer	material 27:8,20	168:2,6 170:8
284:13,14	M69680-015B...	51:10 171:17	32:24 39:23	181:9 182:7
290:13 292:15	280:19 283:12	manufacturers	40:16 41:7,9	197:14 214:1
293:22 294:8	286:22	232:21	41:18 46:13	215:17,22
294:20 316:22	ma'am 15:3	Maple 2:12	47:23 48:8,15	221:21 222:4
327:6 333:24	22:17 26:16	March 5:19	48:22 54:17	242:24 258:16
343:25		28:18 35:13,13	55:7 56:3	278:14 310:5

331:7,14 346:7	272:5 275:25	326:23 328:7	met 19:17 45:20	213:23 229:21
353:25 354:3	275:25 287:19	328:15 331:20	45:22 332:14	230:16 232:12
357:7 362:16	301:12 313:7	332:11 337:21	metamorphic	243:25 244:2
364:11,24	314:13 321:19	345:6 346:13	97:7,9 114:2	249:13 255:1
math 17:8 28:5	323:25 328:20	346:23,25	114:10,13,23	258:3,9,9,9,13
36:5 250:5	328:24 332:1	361:12	method 4:21	258:22 259:5
Matt 20:2 330:9	338:7 348:13	measuring 82:1	49:2 80:13	260:22 263:5
matted 312:19	348:14 356:10	336:6	101:9 106:10	263:22 264:4,6
313:22	meaning 13:3	medal 359:4	106:15,20,23	278:7 295:16
matter 8:8 19:12	78:22 117:8,20	medical 43:10	107:16,19,25	298:21 302:4
75:19 82:18	322:18	144:11	108:18 131:16	335:22,23
110:2 113:21	means 53:4	meet 83:20	135:16,16,19	341:7 342:6,15
117:6,8,12,17	90:14 145:3	217:21 219:16	135:20,22	342:18 347:5
117:22 130:8	211:15 225:16	219:22 220:6	233:6 264:13	351:7 353:7,21
212:21 243:17	225:16 239:13	meets 233:14	272:3 273:18	methods 50:14
283:19	259:18 262:25	Mehrdad	274:9 275:17	54:24 56:5
matters 15:7	297:3 320:19	253:22	325:14 340:4	65:9,25 126:9
25:3	320:19 338:3	Melinda 1:12	methodological	133:22 134:3
Matthew 19:25	meant 183:16,22	8:11 9:17	340:5	143:3 171:10
maximum	measure 60:3	147:8	methodologies	172:4 198:16
279:11 320:3	79:18 80:5,9	member 13:2	24:23 68:25	207:3 341:6
McCrone 5:22	81:6,20 82:5	memo 180:15	86:17 233:7,22	361:16
6:1,3 221:16	85:15 178:5	memorandum	336:6 362:8	Mexican 157:20
221:17 222:10	182:6 219:4	49:6,14,19,23	methodology	162:8 163:10
222:11,15,16	316:24 335:18	175:12 177:11	4:22 16:18,23	Mexico 5:17
222:20 223:1,4	340:8 341:4,11	memorandums	17:2 18:20	153:11 155:2
224:10 225:15	measured 81:3	49:9	19:13 23:11,24	156:10 157:11
227:4,18	185:17,18,19	memory 21:9	24:11,21 55:4	159:25 161:25
228:23 229:16	186:25 197:14	102:3	55:24 56:25	162:25
231:4,7 257:6	329:19 338:14	mention 141:9	57:7 62:15	Mg7(Si8O22)(...
258:14	340:11 343:24	194:24 329:15	63:1 64:2,2,18	90:9
MDL 1:4 35:1	344:25	mentioned	64:21 65:19	Mickey 20:9
104:22 165:9	measurement	56:10 59:20	67:17,23 69:21	33:13 45:21,23
190:18 213:24	4:23 67:23	71:5 81:2	77:22 78:9,13	46:4 59:8
249:6,8 251:22	81:5,9,20	98:20 116:13	80:19 81:11,25	73:19,25 74:10
253:8 326:8	135:20 136:10	120:16 361:23	96:5 98:18	74:20 76:7
MEAGHER	141:4 198:5	mentions 323:4	99:17 101:18	139:23 147:8
1:14	200:11,12,13	merely 333:8	106:2 109:12	153:3 309:3
mean 13:19,20	241:18 344:7	merwinite 191:9	113:13 134:8	Mickey's 309:6
35:4 51:9	345:14,19	192:6	134:11,14	microanalysis
57:22 64:21	measurements	mesothelioma	136:10 143:1	50:18 361:3,7
90:13 94:13	56:11 186:5	5:12,17 45:9	159:16 161:4	361:19
102:9 118:13	198:16 207:23	96:10 99:10	165:24 166:15	microbes 359:25
145:8 183:18	211:12 222:7	144:4,21	168:14 169:25	360:3
190:2 199:12	238:12 242:22	153:11 154:4	171:4,6 197:21	microbiologist
243:10 259:18	260:5 270:4	154:20 155:1	199:4 200:18	43:18
259:19 268:4	271:14 324:13	163:8 310:15	205:7,25	microbiology

43:19	258:25 260:17	99:20,24 100:1	266:1	190:20 191:10
micrograph	288:15	112:20 123:17	mineralogists	192:11,23,24
347:12	microscopic	164:7 224:22	147:4 241:1	193:4 194:13
microns 79:19	65:25 126:9	247:1	mineralogy 5:5	194:15 198:23
80:10,20 85:17	340:12	mineral 6:9,11	5:13,13 45:23	198:25 200:4
188:3 271:7	microscopically	6:13 60:2 66:5	92:12,15	201:10 215:3
315:22 319:19	86:11	70:19 71:10	110:10,24	217:2,12,21
320:4,13,22	microscopy 4:21	72:1 79:15	147:7,7 167:8	218:3,13
322:9,20	4:24 47:16	80:3 84:7 90:7	167:23 169:1	219:22 220:22
323:13 324:20	63:8 65:11	94:12 97:10	191:25 192:15	221:4,5,6
324:23,25	67:24 68:20	112:7 114:11	192:19 201:9	224:12,17,20
326:24 331:25	102:7 116:3	114:23 123:22	214:4,9,14,23	225:14 226:6
335:19	126:11 136:11	125:7,14 127:9	215:1,8 216:15	228:7 231:20
microphones	151:18 196:18	127:11,12,13	216:20 217:5,9	240:13,14,16
121:21 161:8	222:2,13,22	127:14,21	221:2,11	240:23 244:10
365:12	233:6,15	128:18,19	222:23 241:10	255:7 257:4
microprobe	256:18 257:3,8	129:5,7,12,14	267:12 277:16	265:13 271:19
149:24	259:17 271:3	129:16,20	295:2,3,22	292:6 295:2,17
microscope	291:19 351:9	138:2,13	355:2,3 358:9	301:4,15,18
39:14 40:1	351:24 362:25	140:22 145:2	358:16,17,20	328:23 342:17
53:16 72:14	microscopy-b...	149:17 151:20	360:20,21	351:8,15,23
86:6 102:5	50:13	152:2 156:22	minerals 5:15	353:9 359:9,20
116:19 117:3	mid-'70s 232:22	161:25 164:1	11:13 12:2	359:25 360:3,9
117:15,19,25	middle 35:1	181:20 182:19	13:3,9 15:25	360:24 362:16
118:9,17,24	331:13 357:24	191:1 194:11	29:9 60:14,15	364:25
120:4,18,20	Miller 6:4	198:1 201:13	63:9 65:12,15	mines 76:21
121:3 124:15	224:11,16	201:19 210:22	78:20 79:1	77:3,16 87:5
124:18 178:10	million 226:23	213:21 214:21	86:9 91:18	87:24 96:20
178:24 186:3	mind 38:20	215:23 216:7	94:6,25 95:17	97:3 100:3,16
196:2,3 197:9	76:13,17 86:23	227:4,21	96:19 97:3	104:7 105:13
207:17 209:2	107:13 201:14	245:17 257:14	100:17 107:14	159:7,23
222:4,7 237:23	265:20	260:7,23	112:15 113:23	163:19,24
244:20 259:19	minds 160:17	265:22,24	113:23 114:3	164:3,14,16,19
261:16 262:18	mine 18:3 44:19	266:9,14,19	124:11 132:10	164:23 166:24
266:10,15,20	88:5,6,6,7	267:2,5,22	132:16 134:25	167:5,9 170:5
273:12 274:17	163:21 165:1	268:1,3 269:8	135:2 139:14	172:25 173:9
274:24 275:6	168:2,5,9	270:16 277:17	146:23 148:4	175:20 180:18
278:20 279:10	170:20,22	333:19 334:11	151:14 163:20	190:22 191:21
287:21 290:23	174:24 177:19	334:16 341:25	164:7 166:22	192:1,19 214:9
292:6,17	215:2 227:20	342:25 344:17	167:7,20	215:9 217:6
294:21,23	229:25 247:23	361:2 362:11	168:21 169:5	224:22 230:24
296:5,7,11,18	248:16 249:2	mineralogical	170:18,23	231:4,11 241:7
296:25 304:2	249:16,16	93:12 145:22	171:8 173:16	241:7,10
318:17 335:7	255:22,24	173:14 358:22	173:19 174:19	251:10,16,20
359:14 363:5	310:16,18	359:5	184:8,12,14,18	255:18
microscopes	341:15 354:13	mineralogist	184:22 187:6	minimum
50:24 51:6	mined 17:20	144:14 145:21	187:11,16	188:24 189:17

mining 112:24 112:25 164:22	247:13 350:2	208:2,4	174:18 213:4 309:5	276:25 277:2
minor 362:14	monticellite 191:9,15,16	mouthful 125:17 197:19	nature 111:9,15	negate 252:6 253:17
minus 363:18	moon 168:22	move 7:11 63:22	154:3 170:22	neither 72:4
minute 150:16 201:1 203:5 276:17 295:15 316:20	169:5 348:21 348:24	147:17 220:1 298:6	185:20 193:3 265:21,23 311:24	126:11 225:1 366:11,12
minutes 57:17 98:21 102:1 120:9 153:7 273:14 276:1 276:24 277:7 277:13 340:15 346:2 353:4	moot 307:2 Moreau 174:14 morning 9:25 morphologica... 178:13	moving 178:10 MSHA 341:15 multiple 20:7 73:21 115:23 116:3,13 121:7 160:22 196:7 211:4,11 231:10 324:13 326:22 331:19 331:21 332:11	NCRA 366:17 near 120:10 156:10 204:1 nearly 358:8 nebulous 168:12 necessarily 135:1 270:2 275:9,17 necessary 24:22 68:19 86:8 124:9,12 127:5 127:15 128:20 138:3 139:8 149:25 156:17 201:12 270:7 277:23 360:1 367:4	never 10:25 11:6 11:10 23:23 58:15,16 62:1 62:12,14,24 63:5 68:17 74:15 75:12,21 76:4,13,16,23 86:4,7 109:15 147:2 177:13 191:4 222:14 224:18 264:23 265:4,7,15 277:21 312:7 312:14 364:17
misreading 151:7	morphologies 72:22 73:18 184:5 325:15	murky 228:17	need 18:17 63:21,23 66:24 67:3,8 78:10 82:8 85:12 86:13 111:21 131:14 138:6 138:10,14 141:5,8 146:11 146:19 148:15 149:19 152:10 154:6 157:2 162:18 188:11 188:24 189:11 189:18,25 202:1 222:13 222:24 230:5 233:12,15 237:17 261:3 265:15 307:20 327:18 331:19 353:3 363:6	new 1:1,15,15 2:13,17,17,22 7:5,6 8:8,8 44:19 48:19,20 191:17 310:7
misrepresenting 232:1	morphology 70:21 72:6,13 79:6 82:23 182:22 183:9 183:13,15,18 184:10 185:16 186:21,23 187:5,9,17 188:6 193:8 197:6,14 217:16 218:18 219:3 220:16 261:17 267:13 268:10 291:21 292:23 315:11 315:11,14 316:4,14 317:9 317:24	museum 104:24 105:5,19	need 18:17 63:21,23 66:24 67:3,8 78:10 82:8 85:12 86:13 111:21 131:14 138:6 138:10,14 141:5,8 146:11 146:19 148:15 149:19 152:10 154:6 157:2 162:18 188:11 188:24 189:11 189:18,25 202:1 222:13 222:24 230:5 233:12,15 237:17 261:3 265:15 307:20 327:18 331:19 353:3 363:6	Newbury 84:24 125:19 142:23 143:7
missed 58:19 175:2	Mössbauer 50:16 58:4,24 59:21,25 60:9 60:13	murky 228:17	named 28:9	newspaper 45:18
mission 312:1	Motamedi 253:22,25 254:4,11	N	names 213:22 215:24 220:11 220:12	nfinch@motle... 2:8
Missouri 3:8	mother 42:15	N. W 3:2	narrative 66:3	nicely 340:6
misspoke 302:10	Motley 2:7 3:12 8:20	naked 340:13	NASA 11:23 168:24 359:3	night 25:13 246:5
Misstates 82:25 120:24	mount 21:10 51:1 52:6,15 52:19,20 53:13 301:25 349:6	name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	named 28:9	NIST 53:4,5,7 53:25 124:4
miswritten 285:14	mounted 150:6	name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	nomenclature 93:11,15 147:13,15
MIT 43:2,5 357:23 358:6		named 28:9	narrative 66:3	non-asbestifor... 84:7 187:15 188:7 189:21 197:3 270:1 293:1,4,7 295:17 308:22 310:7 311:2,9
mix 215:22		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	
mixture 304:13 305:10 306:24		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	
mock 10:12		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	
model 51:11		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	
modern 346:22 346:24		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	
modified 150:8		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	
monoclinic 116:2		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	
Montana 45:9 58:22 59:15 102:17 140:14		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	
Montgomery 2:5		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	
months 12:4		name 8:1 10:1 20:1,9 21:16 21:19 30:7 59:2 94:12 151:2 153:17 206:11 357:23 357:24 363:23	names 213:22 215:24 220:11 220:12	

318:10 319:2	number 35:11	19:10 30:1	176:7,8 177:12	objects 169:1
319:15 320:1	35:11 41:14	31:9 32:12	178:16 179:9	obligation
322:3 324:10	56:12 70:13	41:1 44:21	180:3,19 182:2	156:24
325:5 331:6,15	101:22 111:5	45:10,11,16	182:15 186:11	observed 209:21
non-asbestos-	189:7,10,18	46:15 62:17	187:7 188:8	320:6,15
132:22	205:12 218:23	63:4 68:6 71:8	189:22,23	322:21
non-Mount	219:15 235:24	71:24 73:23	191:23 194:21	observing 186:6
11:25	243:10,21	74:7,8,17,18	197:17 202:5	obtain 130:11
non-peer-revi...	254:4 280:12	75:11 76:11,15	205:23 212:7	277:23
330:19,24	280:15,25	77:20 78:6	214:12 215:5,6	obtained 96:20
non-planetary	298:25 299:8	80:21 82:11,24	216:2,23	103:16 166:25
11:25	302:14 319:6	83:1,2,23	217:23 219:18	190:23 191:22
Nonasbestiform	330:3 350:14	84:15 85:18	219:19 220:1,8	209:17,19
6:9	350:15 352:17	87:7 88:8	220:9 221:7,8	210:11,13
nonempty	363:14	90:21 91:8,9	224:25 226:1,9	214:11 253:16
302:15 303:15	numbered 28:23	94:1,2 95:13	227:23 229:2	obtaining
nonfibrous	289:4	95:25 96:1,2	229:17 230:12	203:19,21
173:20	numbers 17:8,9	96:12,22 97:4	231:22 232:25	obtains 66:11
nonresponsive	38:1 77:9	97:15,23 98:13	233:1,10,11,25	obvious 202:8
147:18	88:23 90:16	98:14 99:12	238:20,21	obviously 7:14
nonunique	125:3 141:22	100:5,6,20	239:15,16	22:4 88:19
244:15	141:25 165:18	103:8,20 104:9	244:3 248:17	287:1 288:23
Nope 330:7	198:24 205:17	105:1,14,15	248:18 250:1	356:10
norm 142:4,14	227:14 274:13	106:17 108:23	251:6,24	occasion 62:2,25
normal 283:21	282:21 300:9	109:5,6,25	252:13 253:10	Occupational
304:25	300:13 302:24	110:17,18	257:21 258:17	341:14
North 102:18	337:22 338:10	112:9,22	259:7 260:24	occupied 304:1
Notary 366:18	339:13,16	113:10,11	261:19 263:3,7	occur 254:25
368:19	numerous 64:14	114:6,19 115:3	263:25 270:9	270:15 276:12
notation 226:14	79:9 85:1	118:20 119:19	285:21 293:25	312:18 313:21
239:11	NVLAP 53:3,7	120:23,25	294:14,15	314:17
note 108:7	53:24	132:2,24	296:8 310:10	occurrences
144:10 232:2	NW 2:8	135:11 141:19	310:19,22	164:16
262:5 314:25	<hr/>	142:21 143:17	311:3,4 312:2	occurs 97:8
315:2 317:3,9	O	146:7 154:5,23	312:13 314:22	October 28:17
325:10 349:18	O 3:14	157:14 158:16	318:2 323:14	29:18 34:22
noted 32:6 87:19	O'Dell 2:3 7:1	158:17,18	327:20 329:9	35:19
218:12 262:6	7:20,22 8:21	159:9,10,14	332:3 334:1,21	Oczypok 5:17
367:10 368:7	8:21	160:2,3,15,24	339:1 341:18	odd 254:3
notes 297:25	oath 9:15	160:25 162:14	341:19 342:1,2	offer 104:2
370:1	object 10:17	163:4,22 164:9	342:23 344:10	office 12:14,18
notice 4:11	30:9 32:1	164:10,24	347:24 348:9	12:20,23 21:10
14:24 15:12	33:20 34:10	166:9 167:1	348:15 350:5	offices 1:13
235:19 342:10	36:24 37:8	168:10 169:12	351:17 352:8	oftentimes 75:2
November 5:23	298:5	170:6,25	352:19 353:12	oh 27:17 50:16
28:16 34:20	objection 7:2	171:22 173:3	objective 316:21	150:20 199:15
35:1,21 224:2	11:2 16:11	175:14,15	317:23	203:5,15 210:6

223:2,20	246:1,11,20	237:21	101:18 106:24	341:13
233:12 280:9,9	252:8 256:4,8	operators	117:7,17 118:1	out-of-context
282:22 292:22	257:5 259:23	215:20	125:13,24	260:9
295:1 300:14	261:7 265:6,19	opine 96:6 176:5	126:4 127:7,13	outdated 120:6
347:18 363:19	266:6,25	176:10 180:16	127:20 128:13	outer 168:21
oils 219:6	267:18 269:21	opinion 18:24	128:19 129:1,5	outlier 332:1
271:16 275:19	272:21 278:17	19:5 25:2	188:23 189:19	outlined 358:4
okay 7:25 9:13	280:10,11,14	44:12,16,17,22	199:18 201:13	outmoded
15:15,21 16:15	280:18,21	44:25 45:3,4	202:2,3 224:5	348:14
18:21 26:10,16	281:9,18	69:5,10,24	230:8 237:17	output 142:12
26:22 27:11,15	282:23 284:19	70:5 76:3	243:23 252:5	145:10 148:15
27:17,24 28:7	289:9 291:25	82:16,17,20	259:24 267:7	149:1,19
28:22 29:3,11	296:2 298:19	83:10,14,16	269:10 316:13	152:13
29:17,24 30:21	299:3 300:19	84:23,24 86:2	324:14 331:21	outset 160:5
36:2 37:17	300:21 301:2	96:8,14 97:16	336:7	outside 102:22
38:5,16,19	302:20 303:4	112:17,25	orders 339:10	113:15 229:19
40:13 41:15	308:9 309:15	113:3 115:7	ore 18:3 163:20	252:11
53:3 55:3,21	310:1 314:12	145:20 146:21	163:21 164:7	ovarian 8:15
56:18 57:5,16	315:19 319:5	166:21 168:15	166:25 226:20	10:3 62:24
58:10 59:2,20	319:12 322:17	169:22 175:18	227:20 231:11	96:10 103:1
61:7,18 62:1	323:8 328:18	176:11 178:3,4	232:9 260:12	160:22
62:12 66:17	337:12 345:21	178:7 195:2	orebody 257:13	overlap 107:14
71:4 77:14	346:15 347:19	223:7 232:15	257:14	overlapping
88:24 89:3	349:10 353:6	232:16 233:17	ores 170:3	107:11
90:3 91:21	354:9 355:2,14	234:2 243:23	173:14,25	override 317:6
93:20 95:3	363:21 365:10	288:20 292:12	organization	317:15
104:2 107:22	old 42:15 92:15	335:25 347:9	61:20 93:25	overriding
113:18 116:12	311:20 346:14	348:17 353:5	95:12 330:9	317:11
120:14 121:18	348:3,12,14	opinions 22:9	349:23	oversee 50:23
121:20,24	omnibus 217:25	25:7,7 190:11	organizations	overseen 51:1
130:13 133:3	once 19:18	233:21 330:16	53:11	owned 100:16
134:21 158:9	29:13 229:10	opportunity 7:9	organized 29:9	170:22 173:9
161:7,11	332:5	7:13,16	orientation	224:21 227:20
163:18 164:5	one-day 24:5	opposed 287:6	209:20 210:14	owners 164:19
165:7,14 166:2	ones 53:11 73:18	310:8 344:8	210:23 218:11	ownership 13:4
172:17 175:10	79:1 90:24	optical 5:13	orientations	354:17
176:4,13,24	91:12 160:8	147:7 201:16	136:15 204:1	oxidized 60:4
183:23 187:20	229:24 272:19	222:2,13,22	209:22 212:11	oxygen 60:1
188:2,14	287:18 288:12	233:5,15	origin 102:13	
193:25 203:13	289:4 306:4	274:22 277:15	original 219:11	<hr/> P <hr/>
203:24 206:13	open 7:12,19	289:25 290:2	290:20 367:14	P 2:1,1 3:14
210:6 213:9,12	opened 104:13	326:9 355:2	Orrick 2:15 9:1	p.m 25:15 161:9
215:14 223:24	105:7,20	optimal 83:12	14:11,12	161:10,13
225:13 229:11	operating 41:3,5	151:18	orthorhombic	213:10,11,14
234:19 236:21	164:23	Oral 4:11	116:2	256:6,7,10
238:13 242:10	operator 208:19	order 64:3 82:8	OSHA 93:24	308:7,8,11
243:9 245:7	213:23 215:16	82:21 83:19	173:19,19	343:10,11,13

365:13,16	299:22 300:7,9	155:6,22	135:7,9,22	253:25 254:1
page 4:2,10 5:14	300:12,20,22	156:12 157:4	150:12 155:4	293:1,4,7
28:22 33:1,4	300:25 302:21	157:17 159:24	165:18 167:20	295:19 296:1
40:5,10 66:3	302:24,25	161:22,24	167:22 168:3	301:4,14,20,22
73:5,6 78:19	303:21 308:15	162:3,16,19,22	169:3,6 170:20	304:6,14,24
78:19 79:10	308:18,21	163:3,14 174:6	194:10 208:19	305:2,10
89:10 92:21	309:24 312:17	185:3 202:10	225:8 232:6	306:17,24
95:4 111:2	313:9 314:6	261:2 290:12	239:2 267:9,10	308:23 311:9
123:21,24	315:8 319:5,23	292:24 293:2,5	267:11 295:12	321:11,15
125:1 126:21	331:15 336:25	293:8 309:2,3	319:13 330:15	323:12,20
132:3 133:21	337:1 345:1,10	310:2 311:14	348:22 354:4	324:1 326:11
134:23 138:18	345:22 347:10	333:11 338:3	356:13,22	327:16 328:21
144:25 147:12	369:3 370:3	345:4 348:1	360:19	331:21,24
147:23 148:24	pages 7:6 27:21	362:2 364:18	partially 35:7	336:13 340:8
148:24 150:1	27:21 89:14	364:19	particle 70:21	340:12,12
150:21 154:18	130:23 141:23	papers 19:24	72:6,13,22	342:12
172:22 173:11	148:1,10	20:8 43:19	73:2 82:7 85:6	particles'
177:16 179:14	162:16 180:13	46:8,10 51:14	85:12,13 116:5	329:19
190:12,14,15	238:5 242:17	58:25 59:1,3,9	117:24 118:8	particular 60:3
199:10 202:22	245:11 257:19	59:10 83:7	119:11,17	68:16 78:20
203:3,8,16	257:24,24	109:3 110:7	120:21 126:5	83:17 93:5
204:5,8 206:4	288:20 330:25	189:2 309:7	129:2 150:6,13	124:23 135:4
209:14 210:3	331:2 368:5	358:11,15	150:23 151:1	139:9 146:10
211:17 212:1	paid 66:21	361:24 362:5	183:10 195:14	146:23 147:1
213:19 227:8,9	349:11 350:1	362:20 363:12	195:21 196:24	149:12,13
231:10 234:8	pair 290:10	364:3,16	198:6 201:6	152:5 168:9
234:14,15	Palouse 11:13	paperwork 29:8	237:22 268:11	169:20 170:20
235:5,9 237:7	12:2 13:3,9	103:24	268:15 270:5	182:22 187:18
238:23 240:11	15:25 29:9	parageneses	271:6,6,12	190:8 201:20
240:24 241:12	paper 17:3	114:21	286:6,8,20	202:15 217:6
245:7,10,14,16	25:22,25 26:23	paragenesis	297:23 304:2,4	218:11 239:13
245:18 247:17	27:1 47:15	98:17	304:7,9 307:19	249:2,4 263:12
271:25 272:7	74:25 75:17,18	paragraph	318:6,11	263:24 285:25
273:20 278:8	101:4,12 102:2	210:5 240:25	323:23 327:19	321:9 327:8
280:7,8,11,23	107:5,7 108:10	319:9 321:4	331:20 340:19	336:1 341:9,10
280:23 281:7	108:16,20	paragraphs	363:4	353:5 358:5
281:18,22	109:12 111:3	89:15 206:14	particles 73:8	361:18 362:9
282:3,10,11,11	111:11 119:21	parallel 289:16	101:22 111:5,7	363:2
282:13,14,17	139:19,23	312:19 313:2	116:6 118:3,4	particularly
282:18,19	141:3,12,16	313:22	119:3 121:8,13	206:18 260:3
283:14 284:4,6	142:23 143:15	paramount	140:15 142:2	362:15
284:7,14,18	143:24 144:11	325:14	154:4 156:6,8	parties 20:13
287:10 288:1,2	144:20,22	Park 2:22	156:19 158:23	366:11
289:3,7,9,10	145:11 150:9	part 19:22 23:3	182:22 185:3	partners 13:7
290:11,25	152:19 153:3,7	32:10 36:21	205:6 226:23	parts 97:20 98:8
298:12 299:4,6	153:16 154:7	81:10 94:14	242:3 243:13	226:22 248:8
299:13,15,20	154:18,22,25	116:1,4 133:21	243:15,17	party 14:5,14

pascal 81:14 344:4	50:6 67:12 68:21 80:7	44:5 196:1 291:14	photograph 33:3 119:16 184:20	279:2 283:5,15 287:22 288:12
pascals 338:15 338:17,21,25	98:11 101:17 108:16 109:13	performing 38:6	photographing 203:21	Pisano 7:23
passed 39:19	119:14 140:2	performs 137:20	photographs 140:12	pixel 235:20 236:14
passes 290:9	141:15 142:17	period 160:5 234:2 297:14	photomicrogr... 33:3 119:17 186:2 293:22	pixels 235:22,25 237:4,5,16,18 238:15
pathologists 146:25	144:6,16 147:3 153:12 155:6	perpendicular 209:9 287:15 289:12 290:3	photomicrogr... 118:8,18,23 119:6 228:23 229:11 261:15 326:12	place 52:7 87:11 146:16 152:17 158:24 232:22 256:3 366:8
pathology 144:12 153:13	201:4 202:10 293:14 332:22 332:25 333:7	person 13:4 16:6 16:7 30:7 163:7	Photon 52:10	placed 39:24
pattern 39:21 40:12,24 41:20 42:2 141:7 199:23 200:15 207:9 208:13 209:5,13,17,19 210:11,13 212:16,22,24 214:17 217:14 218:7 249:19 260:5 262:16 264:12 360:14	pencils 266:1,3 pending 147:18 356:20	personal 3:4 9:12 11:16 82:17 83:10,16	physical 184:17 235:2 344:18	places 37:21 64:14 78:5 79:2 199:14 242:21 254:10 326:22
patterns 69:14 70:9 132:12 148:6,13,13,16 203:20 205:2 206:17 212:12 212:21 213:21 215:15 229:13 238:18 239:1 261:4,8 360:15	people 39:2 77:14,18 93:1 146:24 157:11 167:16 170:21 225:14,20 249:23	personnel 144:11 174:13 237:24	physically 212:25	PLACITELLA 2:11
Paul 281:2	people's 78:11	perspective 334:19	piano 346:18	plaintiff 8:22
pausing 57:14	per-sample 277:13	perspectives 109:23 119:25 211:5	pick 19:18 332:14	plaintiffs 2:14 8:16,18 9:21 10:4
pay 51:12 249:10	percent 182:1 204:12,13 205:5,12,17 218:13 233:9 247:2,2 250:8 250:9,16 251:14,15 306:2 350:10 361:25	PERTAINS 1:7	picked 42:16	plane 41:12
paying 103:24 273:23	petal 187:3	petals 184:9	pictograph 177:23	planet 166:23
PC 2:11	ph 1:23	Ph.D 1:13 9:17 22:19 42:8,9 43:4 358:6 366:5 368:12	pictographs 331:11	Planetary 349:20
peak 125:23	Pharmaceutical 5:7 101:13	phases 86:11 114:12	pictorial 6:10 331:5	plate 39:25 278:20 283:6 283:18,21 286:24 287:11 287:21,24 288:8,18
peaks 155:7,10 155:11	per-sample 277:13	phD 4:12,13	picture 41:19 42:1 119:7 185:1 211:24 285:12 354:11	plates 178:10 283:3
peer 109:17	percentage 70:13 247:20 247:21 248:14 248:14 251:9 253:3 274:6 322:14 349:24	phenomena 361:5	pictures 32:16 118:16 293:18 293:19 331:15	Platinum 155:10
peer-review 46:12,25 47:4 47:9,15 75:1 333:5,11	percentages 245:13,14	Phillipe 174:14	piece 145:16 274:22 290:6	please 8:12 9:14 30:14 32:13 37:17 38:15 55:15 100:22 121:21 161:7 365:11 367:3,8
peer-reviewed	perfectly 226:2	phone 21:11 356:11	pieces 193:13	plenty 296:11
	perform 120:18	phonetic 328:16	Pier 5:21 177:7 177:14 179:6	pleural 5:17 153:10 155:1
	performed 30:19 39:13	Photo 52:9	Pierce 293:8 311:11,15,25 Pierce's 311:14	
			pile 256:15 pink 278:18	

163:8	286:8 298:14	187:12,14,20	159:22	prepare 37:5
PLM 6:7 47:16	298:18,20,25	188:11,15,24	potentially 82:9	106:15,23
54:24 58:1	299:8,25	190:9 196:25	84:6 121:17	prepared 37:2
65:15 71:20	300:18 302:4,6	198:8 317:22	128:15 138:12	297:5
101:25 117:21	302:13 303:9	318:21 322:2	139:13 174:11	preparing 81:13
117:25 119:7	303:20,25	323:23 324:15	195:7 231:20	101:18
119:18 151:18	304:5,10,18	328:20,22,24	240:15 271:18	presence 24:12
186:3 196:21	305:8,20,24	329:19 332:9	322:5	71:2 84:18
217:18 218:25	306:10,22	355:25	pounds 82:4	107:2 115:25
219:2,7 220:16	307:2,3,4,6,10	populations	343:24 344:6	124:22 139:12
264:14 269:15	308:1,2 311:7	73:12,17 83:9	344:25 345:14	174:7 200:19
269:23 270:24	313:4,13 317:3	83:11 116:6	346:9	233:23 265:9
271:7,9,18,24	321:3,18,21	121:12,12	powder 1:3 8:9	265:17 267:2
272:3,4,9,11	323:19 328:5	189:3,5,6	17:16 18:2	267:21,25
272:19,23,25	331:16 340:21	295:18 318:7	19:2,9 44:14	315:20 319:14
273:6,18,25	347:4	319:3 321:8	62:11 65:14	328:22 342:16
274:4,6 276:2	pointed 69:23	323:5,9 324:11	69:18 77:15,17	342:19
277:11 278:3,9	142:15	325:6,11,13	87:25 96:21	present 3:11
281:23 291:13	pointing 329:13	posed 219:12	99:23 100:11	24:11 25:2
298:15 303:20	329:17	position 290:18	103:7 113:6,7	48:10 58:7,13
304:21 305:2	points 41:21	290:20,21	139:15 166:25	71:11 72:2,4,7
315:15 326:9	150:13 302:14	positioned	220:25 231:6	72:10,23 82:21
326:14,22	302:15 303:14	200:14	232:10 260:13	86:2 114:12
328:14 359:9	303:15	positively	262:22 364:7	117:1 124:24
359:10,12,17	poke 79:24	270:25	powdered 351:7	127:22 132:14
plot 322:12	polarized 47:16	possess 79:16	351:22	132:16 138:13
plural 158:21	63:8 65:10	possibility 73:7	practice 213:25	139:15 180:24
plus 137:9	102:7 116:3	possible 40:1	215:15 225:20	191:1 200:2
363:17	117:14,18	65:8,13,13	practices 1:4	267:6 268:9
point 41:25	118:23 120:3	72:24 79:18,21	112:24	269:9,11
57:14 67:10	120:20 121:2	128:21 135:2	precise 250:17	316:13 320:7
68:5 102:8	196:18 197:9	151:19 157:1	350:16	320:16 321:1
108:10 112:4	266:9 271:3,23	161:25 162:24	Precisely 211:18	322:23 325:2
118:21 120:10	273:12 274:17	184:4 198:23	predominantly	349:15
121:19 124:25	291:19 294:21	214:4,8,23	251:21,22,23	Presentation
127:3 128:6	294:23 296:5	215:1,21	preexisting	6:10
137:8 138:7	polarizing	216:15,20	66:15	presented
139:1 149:9	126:10 178:24	217:9 248:13	preface 147:23	139:16 317:7
151:11 152:7	288:15 290:10	248:22 283:5	prefer 61:4	presents 325:25
188:22 200:2	359:14 363:5	300:1,4 305:15	229:6	president
201:3 202:16	poor 337:25	307:15 332:7	prefix 225:8	224:11 225:13
204:11,25	338:6 360:25	340:3,7 360:14	preliminary	330:9
205:24 210:19	pop 325:12	possibly 21:2	83:13	presumably
211:19 212:19	population	94:14 247:24	premier 110:9	117:23 118:7
213:5,7 235:18	72:22 73:1,7	post 358:7	preparation	156:10 175:22
236:19 238:22	73:10 83:6	potential 62:23	106:10,15	215:19 237:24
243:2 255:20	121:17 178:6	75:3 95:16	170:9	presume 59:12

167:5,17 297:22 pretty 119:22 143:21 286:12 291:3 297:20 345:25 previous 24:23 267:4 268:7 286:15 previously 7:8 62:2 111:25 primary 48:25 49:5 52:3 170:19 240:16 principal 174:11 print 124:18 142:8,18 143:11,14 149:8 151:22 155:25 156:17 printed 157:24 158:6 printing 146:3 printout 5:11 125:11 128:12 139:7 143:21 278:13 printouts 128:25 131:5 260:16 prior 35:2,3 62:13,22 63:19 67:6 69:23 122:4,10 251:20 366:4 pristine 104:19 privileged 32:3 privy 93:2 probably 26:1 28:15 36:15 53:17 115:16 131:16 143:20 172:11 201:15 220:18 256:2 276:25 308:4 320:1,7,16 321:1 322:23	325:2,8 348:4 348:4 365:1,7 probe 50:18 79:22 85:23 86:4 361:2,7 361:18 problem 25:17 174:16 188:20 271:2 problems 105:17 270:20 procedure 41:3 41:6 104:22 203:17 303:6 303:10 353:10 procedures 234:3 304:21 353:18 process 26:1 40:10 41:15 137:11 processed 225:10 produce 156:25 304:11 306:23 produced 16:4 35:13,15,17 133:14 171:5 191:4 226:7 230:24 producers 174:1 produces 207:8 207:12 product 1:5 5:1 10:17 30:9 32:1 33:20 34:10 36:24 37:8,13 47:1 77:4 123:9 133:14 135:8 135:10 170:18 170:20 232:10 production 4:15 7:5,11 25:13 225:6 227:22 230:1 products 1:4 3:4	9:12 18:2 66:5 76:22 102:19 104:6,8 105:12 123:18 132:9 133:15 170:3 174:2,4 231:13 profession 358:14 professional 265:7,16 professor 32:2 61:6,7 88:18 101:2 102:14 144:3 213:16 308:13 343:17 349:4,14 351:4 357:25 363:22 364:1 profile 190:8 334:12,17 profiles 6:11 333:19 program 53:25 210:9 project 29:4 36:3,8 280:25 projected 304:1 prominently 360:17 362:4 364:16 pronounce 21:19 153:18 proper 64:15 properly 72:20 269:20 270:12 270:19 271:18 271:21 291:20 properties 6:13 181:21 274:22 289:25 290:2 326:10 337:3 344:17,18 proportion 133:13 304:13 305:9 349:22 proportions 133:16	proposal 17:3 proposed 169:15,16 proposition 199:17 propounded 368:6 Protection 47:21 68:1 protections 37:13 protocol 69:6 70:1,12,14,15 119:14 136:6 202:24 203:4,8 232:18,20 264:17,23 265:4,8,17,22 266:2,23 307:25 protocols 64:9 64:11 69:12 70:7 86:21 115:17,22 120:1 121:15 165:2 232:13 265:2 proton-induced 50:20 prove 71:13,16 provide 31:20 32:16 33:16 152:15 238:10 provided 7:7 27:3,8,12 166:4 205:11 229:1 235:4 246:3 247:7 249:3,14,20 250:6 263:18 328:10 provides 201:21 providing 238:18 proving 210:19 pseudo 207:8 PTI 3:9,9 9:10	9:10 Public 366:18 368:19 publication 46:25 47:9 101:3,7 108:20 128:11 143:22 205:19 329:3 330:20 334:6 335:17 362:2 publications 20:1 34:4 46:12 58:20 67:12 68:22 98:11 330:15 330:18 publicly 349:7 publish 75:5 145:11,23 published 20:7 46:24 47:3,14 50:5 93:6 101:16 109:13 140:2 144:6 147:2,14 153:11,23 174:6 265:8,17 355:11 358:11 361:24 364:17 publishes 51:16 publishing 144:15 153:16 pull 162:3 309:16 purchased 354:13,22 pure 104:18 105:7 purely 152:8 purports 107:8 130:12 purpose 34:18 63:13 125:6 134:19 167:19 180:9 263:20 purposes 11:15 11:17 17:21
--	---	---	---	---

95:24 101:8	137:4,18 138:6	340:20 342:15	142:13 143:13	270:23 279:23
108:1 155:12	138:8,24 139:3	346:22 348:2	144:2 147:5,21	282:24 285:5
180:2,8 187:23	139:7 141:3,13	350:17 352:15	148:22 152:22	286:13 293:20
221:20	141:16,25	354:16 356:20	154:10 155:3	294:1,18
pursue 166:17	142:18 143:5	questioning	157:3,18 159:4	296:16 298:8
336:19	146:5 148:8	32:5	159:5,11,18	300:15 303:3
put 15:3 22:7	149:4,14	questions 9:24	160:11,18	306:11,14
38:15 61:8	151:23 152:13	10:13,24 11:8	161:14 162:20	308:12 310:13
232:21 274:13	156:1,25	15:2 16:14	163:17 164:4	310:23 311:12
283:2 287:21	157:24 179:22	19:14 22:16	164:15,17	311:23 312:6
330:20 343:20	191:5 263:14	26:13,15 27:5	165:6 166:20	312:16 315:1
347:14,16	317:22	30:15 31:11	167:10 168:18	318:15 323:17
348:24 355:6	question 16:3	32:7,14 34:2	170:1,12	328:1 330:1
putting 172:17	19:3 30:14	34:14 37:4,12	171:13 172:14	332:12 333:16
puzzle 193:13	37:16 55:2,10	37:19 38:21	173:6 175:6	334:5 335:4
pyroxene	55:16,20 58:6	41:4 44:24	176:3,12	339:4 341:22
150:24 151:9	62:19 69:23	45:13,19 46:20	177:15 179:2	342:9 343:16
	70:10,11 76:14	55:23 57:19	179:12 180:6	344:13 347:21
Q	76:17 77:13	61:1 62:20	181:3 182:9,23	348:6,11,19
q-u-a-l-i-t-a-t...	80:24 82:13	63:15,24 68:9	186:12 187:19	350:9 351:1
39:10	86:23 91:2,21	71:15 72:11	188:13 190:3	352:1,14,20
qualification	93:20 95:21	74:2,12,21	192:2 195:4	353:23 355:1
357:1	97:18 98:7	75:14 76:12,18	199:6 202:11	355:13,21
qualifications	102:3 106:2	77:24 78:14	206:3 208:3	357:13,15,18
358:3 362:7	109:9 110:15	81:1 82:15	213:15 214:24	363:9,11 365:8
qualified 358:1	136:4,5 137:15	83:18 84:1	215:13 216:12	368:6
qualifier 335:12	137:16,24	85:3 86:3	217:10 219:13	quietly 174:14
qualify 79:5	147:18 160:5	87:13 88:13	220:3,20	quite 54:19
qualitative 39:7	162:19 163:15	91:1,14 92:19	221:15 223:10	197:19 205:16
39:9 62:4	168:12,15	93:19 94:7	223:14,17	207:6 212:13
126:17,25	185:15 186:17	95:19 96:7,15	225:3 226:4,10	217:9 272:12
127:23 132:6	186:19,19	97:1,12,19	228:8 229:8	quotation 40:5,7
195:15	188:19 195:3	98:6,19,21	230:7 231:1,16	40:9
quality 4:16,18	198:13 212:9	99:18 100:14	232:5 233:3,18	quote 290:14
61:15	217:25 219:9	101:1 103:11	233:20 234:7	291:1 298:23
quantification	219:11 220:4	104:1,20 105:8	234:20 236:7	299:14,16,19
339:25	220:19 250:19	105:23 106:21	239:8 240:4	300:1 302:16
Quantify 303:8	253:13 255:19	109:1,10	242:23 243:8	302:17
quantitative	257:1 263:9	110:12 111:1	244:16 246:23	quoting 202:22
66:1 84:5,20	264:2 265:14	112:5,16 113:2	249:5 250:20	
125:3,12 126:2	266:5 268:13	113:17 114:14	251:13 252:7	R
126:16 127:6	268:17,23,25	114:24 115:10	253:1,20	R 2:1 3:14,14
128:8,12,20,21	269:7 296:17	119:1 120:13	256:11 258:1	R-93 73:11
128:24,24	296:22 297:15	120:15 121:10	258:23 259:22	189:4
129:10 130:11	313:24 317:2,3	122:2 127:2	261:6 262:8	Railroad 5:2
131:7 132:6	317:19,20	132:19 133:2	263:4,16	Railway 123:2
136:13,18	335:2 339:20	135:14 139:22	264:21 267:4	Rainbow 88:6

raised 156:9 162:8 163:10 Raman 50:21 random 230:17 233:14 248:2 248:25 249:3 252:17,24 253:3,5 randomly 249:17,22 253:7 range 90:15 241:4 265:2,13 304:14 305:10 306:25 307:12 315:20 320:5 320:14,23 322:6,21 324:6 339:9 ranges 107:10 ranked 109:20 109:23,24 rare 141:6 192:23 262:4 rating 110:3 ratings 110:6 ratio 60:14 72:16 82:21 83:5 183:17,19 183:21,24 184:1,2 185:17 185:20 186:6 186:25 187:13 187:23 255:17 261:18 316:20 318:22 320:3,9 320:14,23 321:2,10,21 322:10 323:12 323:25 324:6 324:25 325:23 327:3,8 328:2 329:1,7,12,18 331:24 332:1 ratios 58:5 59:19 84:21 189:19 193:21	193:23 217:17 218:19 269:16 269:24 270:3 315:20 317:21 319:19 320:5 322:15,20 323:21 324:17 324:19 325:21 326:11 327:7 327:11,15,18 329:16 332:2,9 re-read 86:23 reach 7:24 57:13 213:4 306:9 read 17:6,11 18:22 45:17 55:19 106:12 110:7 137:23 160:7,16,19 162:17,19,21 163:6,14 165:4 168:4 170:21 225:12 257:23 259:14,15 280:17,18 304:16 305:7 320:10,11 340:16 342:5 346:3 351:20 352:24 367:3 368:4 readers 75:16 readily 204:19 reading 99:16 100:8 335:2 338:3 real 286:11 reality 174:15 really 36:9 56:16 76:3 78:10 109:9 152:10 167:18 168:11 176:17 176:22 178:3 185:14 218:20 218:21 240:21 266:4 273:24	277:17 283:19 306:4 331:19 realtime 1:18 40:17,22 208:25 211:2 237:22 244:21 366:3,18 reason 7:18 16:3 239:18 249:1 252:18 278:5 367:5 reasonable 106:25 168:3 170:16 307:8 reasons 11:20 143:20 Reath 2:19 9:4 recalculate 238:16 recall 42:14 46:19 47:2,7 47:13,19 51:23 51:25 52:2 58:10 77:6 86:25 87:3,12 87:21 92:5 99:6,15 103:22 103:23 108:24 126:7,12,18 160:9 162:2 189:6 241:25 242:4,8 243:14 273:21,22 274:12,14 283:9 285:23 287:17 291:10 291:18 327:24 335:21 342:3 350:22 receipt 367:15 receive 13:7 349:21 received 7:4 32:20 249:8,12 358:18,25 receiving 11:18 reciprocate	38:20 recognition 208:17 359:1 recognize 135:15 147:22 154:11 330:8 recognized 11:10 48:13 201:3 316:9,10 318:18 recommendat... 11:16 244:6 264:11 recommended 121:15 204:12 reconsidering 253:18 record 8:1,13 10:2 38:23 60:20,21,23 61:2 121:22,23 121:25 161:9 161:10,12,16 213:10,11,13 213:17 256:6,7 256:9,12 308:7 308:8,10 343:5 343:6,7,8,10 343:11,13,18 347:17 354:11 354:21 365:15 recorded 347:19 recording 203:21 records 36:11 recreate 325:24 red 2:13 282:10 redacted 16:7 30:3 37:21,23 293:18 redaction 30:5,7 redactions 16:6 REDIRECT 363:10 reduce 145:17 reduced 60:5 redux 59:19	60:14 refer 73:17 235:11 247:15 reference 66:14 83:8 124:5,16 124:20 131:11 135:3 155:16 234:9,25 236:22 300:21 309:8 361:23 referenced 61:24 355:20 references 17:10 160:6 166:18 340:18 355:23 referred 73:12 186:9,14 260:2 294:9 309:9 356:16,25 357:3 referring 12:19 40:8 108:21 125:2 134:15 139:10 203:2,3 203:9 206:17 288:1,11 289:5 299:3 303:15 319:22 357:19 refers 39:17 66:9 82:13 143:18 185:16 200:14 207:15 207:18 235:13 302:5,5 303:7 303:20 317:14 reflected 273:19 reflective 279:12 reflects 28:17,18 29:18 refracted 219:6 refractive 108:7 150:25 151:17 196:22 197:15 271:10,14,16 275:18 291:6,7 refresh 102:2
--	---	---	--	--

regard 56:18 221:19 270:7	relationship 6:9 346:25	161:8 365:11	139:4,11,24 140:1 141:18	347:8 349:12 352:10 355:20
regarding 44:18 46:25 47:4,15 201:23	relative 200:16 304:1,3,8 366:11,12	removes 111:8 render 175:18 178:7 233:17 347:9 348:17 353:4	142:22 146:6 148:9 149:5 151:13,24 152:11 153:9 155:5 156:3,4 156:7 158:3,4 162:6 166:1 170:10 174:24 179:23 184:19 190:14 195:9 197:22 199:10 200:3 202:13 203:6,7 206:2 210:20 211:19 212:19 213:20 213:24 216:19 226:19 229:7,9 229:15,24 230:11,15,18 234:9,16 237:8 245:8,22 250:7 253:19 257:5 257:19 258:15 259:6 260:2,22 264:9 267:17 270:19 273:23 274:12,14 278:14 280:1,7 280:8,11 281:14 283:11 284:9,13 285:1 287:18 290:12 292:22 295:15 298:13,17 300:22 302:18 305:21 307:3 308:15,17 311:8 312:17 313:20 323:7,8 325:17,18 327:5,14 332:8 332:21 333:9 334:8 340:6 342:21 343:2 344:1,4 347:5	358:2,4,5 reported 337:22 338:16 reporter 1:17,18 9:14 25:19 55:20 366:3,4 366:4,17,18 reporting 69:13 70:8 154:19 227:3 reports 16:19,24 17:10 18:12,14 18:16,18 30:24 31:8 32:19,21 32:25 33:5 34:19 35:3,4 42:16 77:8,13 87:21 89:9 100:9 112:13 140:6,10 158:21 160:10 165:8,9,15,16 165:25 166:3 166:19 171:5 180:22 190:18 204:24 211:11 231:3 239:1 245:25 246:25 247:9,17,18 248:1 249:7 255:5 272:2 273:3 276:12 291:11 304:20 305:16 310:5 326:9,10 327:15,17 333:4 represent 10:3 205:5 224:20 243:22 representation 246:18 255:6 representations 255:4
regardless 286:24 307:5	relevance 99:16	renders 107:15		
region 162:9,12 163:11 310:25	relevant 56:16 106:1 161:2 165:23 166:16 171:3 187:10 187:17 193:19 194:11 225:5 249:12 274:4 277:24 278:7 307:7 341:9	repairman 156:9 162:7 163:9		
Registered 1:17 366:3,17	reliability 302:12 339:20	repeatedly 50:11		
registers 272:11	reliable 55:5 56:1,20 69:7 70:1 107:1 229:16 233:24 339:17 340:22	report 4:13 5:4 5:16,20 16:10 16:13,21 17:4 17:6,12,13 19:5 22:8,13 22:19,23 24:25 28:2 30:23 31:8,18,24 32:17,18 33:9 34:4,13,17,25 35:9 40:6 54:19,21 56:24 61:17,25 64:13 65:8 67:18 68:1,12,15,24 72:21 73:4 77:11 78:18 79:2 81:13 83:8,17 84:3,9 88:16,20,25 89:1,5,6,8,11 90:2,25 91:13 92:5 94:5 95:4 95:18 96:4 97:25 98:24,25 99:7,14,16 104:17 105:25 106:8,13,19 107:17,20 108:13,14 110:23 123:22 125:13,20 127:7,17 128:13 129:1 131:8 137:5,19		
regular 295:12	reliance 357:9			
regularly 48:3	relied 189:17 265:8,12 354:4 356:13,22			
regulate 341:16	relies 271:3,10			
regulated 89:16 90:19,23 91:7 91:11 93:23 94:5 95:10,15 95:16 127:12 127:14,21 129:19,25 139:13 197:13 228:6 269:8 270:16 342:25 344:24	rely 62:3 80:7 205:20 265:16 293:11 329:4 329:10 330:14 333:18 336:5 355:23 356:1 357:7			
regulation 317:15,16	relying 244:1 298:19,23			
regulations 96:6	remained 24:21			
regulatory 95:23	remaining 353:4			
relate 235:1	remember 15:19 21:25 108:11 124:3 170:11 295:15 364:13			
related 15:14 18:8 34:16 38:3 92:9 106:14 240:17 356:9	remembering 311:20			
relates 187:5 342:16	remit 229:20			
relating 37:24 47:22 49:9,15 49:19,23 56:12 69:17 76:20 77:2 108:21 141:17 164:15 205:8 343:2 353:16	remove 121:21			

representative 135:1 203:22	ResearchGate 5:11	238:6	8:20	300:24 301:2
represented 271:15 324:15	reserve 7:22	review 7:9 16:17	Richard 330:8	302:7 303:10
332:10	resolution 195:12	16:22 17:24	richterite 89:20	303:17,24
reproducible 240:2	resolve 209:18	18:6,10 19:12	319:16	308:6,21
reputable 109:3	resolved 363:4	19:15,20 20:16	ridiculousness 286:3	311:13 312:21
333:23	Resources 273:19	20:25 23:10,13	riebeckite 79:4	313:9 315:6
request 38:10	respect 34:13	23:17 24:17,23	right 7:23 13:25	317:13 320:17
74:3 76:9	201:24 345:6	31:2,7 32:23	14:9 18:23	323:18 326:16
requests 38:14	respond 32:4,13	34:3,18 62:25	27:2 28:5 36:6	327:9 328:3,24
require 125:11	33:23	77:22 78:13	38:9 46:22	329:1 330:2,25
126:2 128:17	response 98:20	88:24 98:17,18	58:19,23 59:3	337:6,16,20,23
129:9 137:2	339:22	101:6 125:18	59:23 60:17	338:18,22
203:25 208:18	rest 169:23	126:8 157:17	94:23 95:9	348:21 351:16
required 156:1	248:8	159:15 161:18	101:11 106:5	357:6,12
requirement 329:5,11	restate 19:3	166:7 168:14	106:12 117:2	363:16,17
requirements 43:1 128:17	30:13 55:16	169:7 195:1	119:5 123:21	364:3
requires 127:11	186:18	250:5 293:13	127:3 130:19	Rigler 5:4 16:18
128:11 129:17	restrictive 240:19	327:22 333:10	130:22 134:6	18:11,20 19:13
137:17 199:17	result 173:22	339:15 347:4	136:16 144:9	21:2 23:12
200:19 202:25	277:23	reviewed 18:12	154:17 155:4	31:3 32:19,21
203:10 207:23	resulting 39:20	18:14 20:3,11	155:15,23	32:25 33:4
290:13	results 18:1	23:23 61:23	157:12,19	34:19 56:25
research 17:5	65:16 78:2	62:14 63:6,7	160:14 161:5	69:21 77:5,8
52:7 62:7	107:5 146:4	63:18 66:20	168:23 172:22	77:19,23 78:2
63:12 66:23,25	162:7 190:17	67:5 68:11,15	177:16,22	80:14 81:11
67:11 80:15,23	209:17 210:11	68:17 69:16	185:23 189:13	87:21 89:15
81:23 83:15	227:4 232:8	73:12 76:19,23	190:12 191:14	98:2,4 112:13
85:25 86:8	272:19 274:11	77:1,7,9,18	193:7,12 200:6	113:14 125:2
97:17 99:3	275:23 304:11	88:19 99:7	202:18 203:4	139:11 142:10
152:6,6 165:4	306:3,23	102:25 103:4	207:19 209:14	156:20 158:12
222:21 265:11	307:22,24	103:10 108:15	210:7 223:11	159:12,16
292:20 333:8	323:22	109:17 113:4	223:19 224:3	160:7,17
336:1 348:22	résumé 42:23	159:6,20 165:7	224:19 225:4	165:25 180:22
350:14,19	retained 62:22	166:11 170:9	227:7,17 234:8	190:18 191:4
359:2,22 360:1	123:16 168:1	242:25 353:15	234:17 237:8	194:25 197:22
360:16 361:18	retention 63:19	356:13,21	243:4 245:10	198:18 204:24
362:1	return 90:5	358:12	246:4,9,20	205:7,11,21
researched 113:16 115:6	261:2 347:3	reviewer 16:25	253:21 256:9	213:24 214:18
334:3	367:13	reviewing 17:3	260:14 271:25	217:7 232:12
researchers 168:7 222:24	reverse 224:4	40:21 96:4	276:10 277:19	237:25 240:1
	268:7	255:13,15	278:8 280:9,22	241:14 246:25
	reverse-engin...	296:4,10 358:4	281:10,15	258:4,10
		revised 147:13	283:16 284:2,3	264:10 270:12
		revision 93:10	285:1 289:8,10	270:22 272:2
		rewritten 93:16	292:19 298:9	272:19 274:5
		Rice 2:7 3:12	299:5,11	297:21 298:13
				304:20 305:16

305:22 313:5	119:24 196:7	217:3,14 218:7	289:20 297:4	133:22 134:3
321:11,16,20	279:10 289:14	219:22 220:15	305:17 332:10	Sanchez 19:25
322:8,14	rotated 287:10	234:22 237:6	359:18	330:10
323:11 325:17	289:1 290:23	256:23 257:3	samples 5:3 23:4	Sanchez's 20:4
325:18 326:8	rotating 40:16	259:12,18,21	48:8,8 49:11	Sandra 3:6 9:8
328:17,25	rotation 208:7	261:4,7 262:16	49:16 51:21,24	sandra.wunde...
329:20 335:23	rotations 286:16	263:13 266:22	56:11 58:5,8	3:7
340:2,5,9	ROTH 2:11	266:25 267:19	70:13,13 77:16	sat 46:4
341:6 347:6	rough 124:24	267:24 268:8,9	98:1,3 99:23	satisfies 209:11
353:8,22 358:1	routine 295:2	268:11,14,17	100:11 101:25	satisfy 46:18
Rigler's 16:24	359:15	268:22 269:15	102:4,14	200:4
23:18 30:24	routinely 63:10	269:23 360:10	103:15,17,25	save 89:5
33:9 100:9	63:11 181:12	360:14,15	104:12,22,24	saw 61:23,24
158:20 244:25	361:17,22	Safety 341:14,15	105:4,5,18	180:21 237:1
342:11	364:15	Salaries 349:6	106:3,6,7,9,16	344:1
rigorous 319:4	row 247:11	salary 349:4,9	121:14 124:16	saying 31:3
rigorously 174:5	rows 209:8	349:13,22	130:24 134:25	152:10 183:20
Ritchie 84:24	royalties 354:19	sale 225:6	146:15 189:8	199:7 211:13
125:20 142:23	Royston 3:9	SALES 1:4	189:10 205:15	236:21 244:9
143:7	9:10	salt 273:10,11	207:22 217:7	250:12 284:13
river 191:18	RT 310:4,18	sample 39:19,23	225:5 226:20	288:19 329:22
RJ 122:20	rule 115:14,25	40:11 50:1	226:24 227:19	says 9:20 24:14
330:12	Rutgers 174:6	54:16 55:7	228:3 229:24	37:20 42:23
RN 6:4		56:2 57:20	230:21 231:11	56:10,13 69:4
Robert 334:13	S	58:11 70:24	241:17,22,25	70:14 90:2
robust 56:6	S 2:1	71:11 101:22	242:1 243:12	102:16,21
rock 97:7,8	SAD 204:15	106:23 115:12	243:14,22	111:11 127:5
177:3,18	SAED 39:16,17	116:6 118:5,15	247:1,22 248:1	128:7,23 132:1
359:16	39:23 40:11	120:17,21	248:10,24	133:9,19 134:2
rocks 42:16	47:11 58:8	121:9 124:5,20	249:8,15,21	134:5,19
114:2 163:25	69:14 70:9,19	129:19 135:18	250:13,22	137:10 138:8
164:5 167:6	71:5,9,25	145:17 155:12	251:19,22	138:10,23
168:20 192:16	72:18 85:4,10	155:17 171:15	252:10,17,21	139:2,6 140:19
348:20	116:15 117:10	171:18 182:12	253:5,7,9,15	142:17 151:8
Roger 224:10,16	117:20 120:19	183:6 197:4,10	254:23 255:23	151:13 155:14
Roggli 143:24	136:14 181:18	207:16,25	256:21 257:7	155:18,23
144:5 153:6,16	195:24 196:1,8	209:8,9 215:22	257:11,13,16	157:22 163:9
role 113:12	196:9 197:8,24	227:14 262:11	258:5 259:3	169:24 175:9
232:11 335:21	197:25 198:2	263:24 268:19	260:10 262:21	176:16 177:6
rolled 287:6	199:8,17,23	268:25 269:13	263:18 272:25	179:18,20
289:22	200:20 201:5,7	272:23 273:10	278:3 293:16	188:22 200:23
rondorfite	202:2,25	275:3,21 276:2	297:13 304:23	201:5 203:8,12
191:10 192:8	203:10,19,25	276:5 280:12	306:17 307:5	203:16 204:3,6
rose 184:9 187:3	204:15 205:1,9	280:14 281:10	307:15,18,24	204:11 210:10
rose-petal-sha...	206:11 213:20	281:11,12,13	315:15 322:4	210:18 212:1
185:22	214:17 215:15	281:23 283:12	322:14 324:14	223:23 227:11
rotate 40:2 41:8	215:23 216:8	289:11,15,15	sampling 62:4	228:5,9 248:24

254:15,16	86:17 107:1	315:7 316:3	302:7 308:24	25:18
260:4 261:2,23	119:15 125:13	317:4 318:17	315:17,18,23	senior 349:19
271:15 280:18	134:8 168:1	319:6 320:24	318:3 319:10	sense 41:24 44:6
281:16,21	170:17 171:19	324:5,5,18	330:22,23	97:7 116:7
284:2,11	177:10 178:9	326:18 352:2,5	335:7 337:4,5	124:24 244:6
287:15,16	193:10 194:1	Security 38:1	337:8,11 338:2	senses 243:16
288:3 290:16	195:19 228:21	sediment 262:11	340:13 344:20	sensitive 272:10
291:3,11	229:4 239:12	see 7:20,21	345:1,3 346:11	361:7,8
299:10,17	265:21,23	17:13 19:4	346:12 352:4,5	sensitive-enou...
302:9 303:8	268:18 269:10	23:4 26:16	354:10	181:24
305:14 306:22	276:7,11	28:20,21 29:1	seeing 103:23	sensitivity 272:4
307:21 313:16	277:20 330:13	29:22 46:18	342:4	sent 23:6 25:14
314:25 315:19	349:19	55:21 64:14	seen 15:6 67:5	34:20 257:16
316:8 317:4,17	scientists 52:11	73:5 78:11,19	88:19 101:3,4	sentence 125:18
318:17,24	52:12 78:3	79:25 89:25	172:19 185:12	183:13,15
319:1 320:12	85:2 144:5	90:1,10 93:2	246:2 248:4	197:19 239:3
320:18,24	161:23 162:11	103:12 106:13	250:15 271:7	325:9
321:5,9 322:24	162:23 169:8	111:10,11	271:23 285:13	sentences
323:1,2 324:8	222:22 334:20	125:8 126:22	287:22 312:20	207:20
324:23 325:10	scope 133:20	128:3 136:3	330:5 351:10	separable
338:23 339:3,7	229:19	140:18 145:5	sees 111:7	193:15 194:7
340:17 346:4	Scotts 122:23	145:18,19	seldom 207:23	312:18 313:21
346:21 348:1	screen 26:17,19	146:16 151:12	selected 40:23	separate 107:25
351:21	28:14,23 245:1	153:5,14,21	42:2 47:10,10	108:4
scanned 235:21	search 276:24	154:15 155:13	203:18,20	separated 78:23
scanning 178:9	searched 277:1	155:14,18	204:6,14	separately
186:4 266:20	second 5:4 88:15	165:14 175:7,8	256:19 257:8	257:17
scenario 189:11	144:25 145:8	175:19 177:4	258:25	September
school 15:20	149:9 177:16	177:20 179:3	selection 252:16	35:16,17
science 11:25	179:14 209:19	179:10 204:21	self-respecting	series 16:19
51:2 52:23,24	210:13 227:8	204:22 208:10	145:22	28:15 89:18,21
53:1 59:5	257:15 281:22	209:2,25 210:1	SEM 50:18 51:1	90:4,19 91:6
110:3,14	319:9 321:7	212:15 218:15	52:19,21 117:5	91:24 94:10,15
168:25 172:10	345:2 354:14	218:17 224:13	118:10 119:18	173:8 226:19
179:25 180:1,7	365:11	225:11 226:6	130:16 140:11	240:6,21
312:11,12	seconds 351:18	227:14,16	143:19 149:2	271:13
348:13 349:20	section 73:5	228:22 234:11	150:12,14	serious 173:13
scientific 17:1,3	120:7 151:24	240:12 248:12	152:14 157:5	serpentine
56:20 154:18	206:6,9 241:12	251:3,18	177:17 179:13	174:18 256:20
156:2 235:17	280:22 281:21	255:22 257:20	196:3 211:2	256:24 257:10
358:12,13	284:15,18	257:24 258:16	303:21	259:2 358:16
362:5	292:23 294:8	259:24 260:21	semi-quantita...	served 48:18
scientist 55:6	297:5 300:16	261:7,11,14,16	125:24 128:2	73:20
56:1,20 57:24	302:11 303:19	263:1 271:13	130:2 131:15	Service 333:25
64:2 65:1,2,20	303:19 305:7	274:24 283:17	138:20 143:5	Services 1:22
66:23 69:7	306:22 313:10	289:2 292:22	195:16	3:15 8:3
70:2,11 75:24	313:13 314:7	299:22,23,24	send 13:20,25	serving 14:6

310:3	SHOWER	191:11	186:25 270:5	240:15,21
set 25:6 28:1	17:16,17 18:2	similar 84:8	304:24 305:18	solutions 92:6
29:11,12,13	18:2	125:12 150:7	307:16,19,22	someone's 38:17
55:4,24 56:19	showing 111:7	199:1 206:21	sizes 270:5	105:20 154:20
57:7 62:15	155:7 157:5	206:24 207:1,6	301:5 340:19	something's
64:18 77:10	287:9	212:13 249:19	363:4	71:17
86:16 231:17	shown 126:3	297:20	SKADDEN 1:13	sorry 8:24
239:14 353:10	127:6 131:7,17	simple 107:13	skimmed 165:11	102:12 136:4
355:24 366:9	137:4 139:3	110:2 193:3	165:22	150:20 234:13
settled 49:3	140:20 141:17	simply 107:9	skip 207:21	254:19 267:13
seven 162:16	145:15 148:9	156:15 157:5	slide 102:5	297:24 302:10
240:12,16,17	149:4 150:7	220:11 245:23	117:25 121:5	308:18 336:25
257:16	151:23 156:2	328:2 333:3	274:3 304:3	sort 67:4 116:10
SEYFARTH 3:1	158:3 237:6	simulated 148:5	slight 94:21	121:7 143:22
shape 72:15	247:8	148:12,13,16	small 26:21	193:18 196:11
183:16,18	shows 124:19	150:4	41:13 56:16,22	209:6 257:1
185:17 186:24	149:1 150:25	single 33:1,2,3	149:9 178:20	sought 17:9
187:3	151:5 226:21	142:16 197:25	182:6 196:17	source 17:16
shapes 184:9	241:2 245:19	208:8 240:20	274:1 280:16	18:8 19:1,9
187:12,21	sic 39:10 40:10	291:17 327:19	322:13 363:4	52:9,10 156:11
share 31:17	126:10 135:5	sir 76:25 132:1	smaller 155:10	160:13 168:6
Sharko 2:20 9:6	139:4 158:3	144:8 307:2	313:2	170:4,19
9:6 38:14,19	275:16 298:24	351:12	Smith 45:24	173:25 174:10
SHAW 3:1	320:14 321:5	sit 80:17 87:2	so-called 101:9	215:21 216:15
sheet 327:12	352:18	220:21 223:3	Social 38:1	231:5,12
367:6,9,11,14	side 289:22	250:4 259:14	society 49:1	247:22 248:15
368:7	sieve 304:23	sitting 21:10	93:12 358:22	251:23 254:6
sheets 229:12	305:1 307:15	189:13 219:14	358:23,24	330:24 333:23
263:2 290:1,4	307:18,24	220:5 354:6	359:4,5	340:21 346:22
327:1 328:8,17	sieved 305:16	situation 118:11	sodium 155:10	sourced 192:20
Shoemaker	306:16 307:5	118:14 174:13	193:1	249:2
359:2	sign 226:3 367:8	321:9	soil 157:11,20	sources 18:3
short 61:3	signature 83:21	situations	161:25 162:25	105:6 201:18
213:17 256:13	83:25 84:12	132:13 363:7	soils 140:13	216:21 250:25
334:24 343:18	130:4 131:6	six 78:20,25	solar 169:1	251:21 311:10
shorthand 47:5	151:5 217:13	90:23 94:4	sold 123:17	335:15 350:3,8
366:4	signed 28:24	95:15,16	167:15 172:25	350:11
show 124:22	29:4,7 225:18	127:12,14,21	sole 13:2,3	South 3:7
129:11 130:24	225:24	129:19,25	solid 89:18,21	southern 140:14
131:3 146:6	significant	132:16 139:12	90:4,10,18	space 143:21
148:25 149:10	136:25 137:1	194:15 205:15	91:6,24 92:6	168:21 196:15
149:12,13,20	222:18 277:8	205:16 216:6,9	94:10,14 240:6	196:16 200:7
152:7 184:20	significantly	242:1 243:11	240:15,20	208:15 289:3
200:3 218:10	93:18 329:20	245:11 254:7	solution 89:18	359:6 367:6
249:25 291:15	signing 367:9	269:8 270:15	89:21 90:4,10	spacial 235:1
showed 161:23	silicates 173:17	344:23	90:19 91:6,24	spacing 181:21
163:2 355:4	silicone 155:8	size 72:15 73:8	94:10,15 240:6	200:4,6 239:7

241:4	119:23 128:8	216:20 217:8	279:14,17	166:3 175:21
spacings 238:24	136:1 148:17	speculate 36:10	282:7 283:1,4	190:11 240:24
240:2 241:14	164:3 189:7	speed 26:1	283:13,16,20	258:24 290:12
speaking 121:3	193:2 201:25	speed-read	285:12,15,19	367:5
135:20 268:6	283:8 287:18	144:20	286:11 288:4	stated 52:20
271:11	Specification	spend 36:18	stake 13:4	90:23 111:24
special 178:23	6:15 351:6	41:16 46:17	stand 38:24	180:4 247:15
278:19 362:10	specified 136:12	54:3,7,11	121:20 216:24	247:25 248:20
362:15	303:10 319:17	156:11 273:6	236:16 243:22	252:15 273:2
specialties 60:7	specifies 133:22	276:19,21	365:10	341:1
60:8,12,15	134:2	364:22 365:2	standard 41:3,5	statement
species 70:20	specifying	spent 36:7	51:20 56:19	105:17 111:19
71:10 72:1	218:22	272:22,24	61:15,20 62:3	178:18 199:10
84:7 90:24	specimen 208:7	275:20 276:1,4	63:19 67:3	199:22 200:23
91:12 92:6,8	spectra 124:6,18	276:5 278:3	98:24 127:4	214:8,16
92:10 94:4,12	126:17 128:14	295:4,7,11	128:11 131:24	216:19,25
127:12,14,21	129:2 130:2,9	358:6	135:3 142:16	224:24 225:2
128:18,19	130:24 134:22	splayed 312:19	142:17 167:22	233:14 236:16
129:5,7,20	134:24 145:12	312:24 313:22	188:22 189:17	236:20 238:23
138:2,5,13	148:3 154:16	314:1,20 315:3	190:2 201:4	247:5 264:8
151:1 182:20	156:15 157:20	315:4	209:16 234:25	299:2 312:1
194:11 210:23	203:22 206:21	split 104:22	275:2 307:25	states 1:1 47:21
213:21 214:1	206:24 207:1	194:19 280:25	353:11 361:1	65:22 93:24
214:21 215:17	spectrometer	spots 207:12	standards 47:22	127:25 138:18
215:24 216:1,7	59:25	208:16 209:13	51:16,17,20	202:1,24 203:9
240:18 245:17	spectrometers	212:16	52:2 55:5,25	206:16 209:16
252:4 267:5	52:17	spreadsheet	56:1 57:6	225:4 231:7
269:8 270:16	spectrometry	87:19 88:23	84:25 125:11	245:4 303:24
304:2,4,8,9	38:25	247:7	128:17 131:11	314:7 319:12
362:13	spectroscopic	spreadsheets	306:2 329:5	334:17 348:7
specific 37:11	50:13	27:23,25 28:5	358:14	350:19
55:13 63:6	spectroscopy	246:2	stands 53:5	statistical
64:20 79:15	39:1 50:16,17	spun 274:9	330:12	187:21 188:23
84:18 98:25	50:21,21 58:4	sputter 145:16	star 149:2,18	269:16,24
107:8 114:8	60:13 125:21	155:11	start 274:2	270:4 295:24
127:12 129:5,6	spectrum 59:21	square 1:14 8:7	338:20	302:12 316:19
132:7 138:1,11	124:10,21	82:4 343:24	started 15:20	317:21 318:6
138:11 157:3	125:25 130:10	344:6,25	29:3,12 75:6,9	318:21 355:24
168:2,3 170:3	131:24 137:3	345:14 346:10	359:10	356:3
170:3 174:20	141:17 143:6	squishing 344:8	starting 224:6	Statistically
184:10 194:10	143:10 149:10	St 3:8	starts 7:3	188:17
210:22 212:11	150:15 151:9	stable 114:9	state 12:5 24:11	statistics 189:10
220:12 253:15	151:14,25	staff 174:24	35:5 48:20,20	356:5
352:11	154:13 155:7	stage 178:19	60:4 62:18	steel 346:18,18
specifically	155:16,20	212:15 290:23	89:16 102:8,11	steering 8:22
63:14 97:11	214:3,8,22	staining 275:16	107:21 125:1	stenographica...
99:15 108:6	215:1 216:14	278:16,19,25	142:1 165:8,19	366:8

step 117:13 195:19 263:23 263:23	strive 361:25 strong 79:11 structure 40:15 40:21 41:9,18 71:7 83:19 84:13 85:6,7 85:11 94:18,20 95:1,2 118:19 119:8 125:14 126:5 127:8,16 129:12 178:11 181:20,22 182:18 183:11 186:5 194:7 195:6,21,23 196:6,9,20 197:8,15 199:19,25 200:16 204:2 208:25 209:24 211:2 212:24 241:2 244:18 244:22 268:12 316:22 326:24 327:1 340:24	studies 6:10 158:8,10,14 170:21 339:19 study 44:6 62:10 102:24 109:21 116:10 132:18 157:3 168:25 169:5 252:17 264:20 348:20 350:20 stuff 11:5 186:22 Su 54:25 115:16 119:21 264:13 271:15 290:12 290:14 291:1 subgroup 240:13 subject 15:7 46:13 48:15,21 75:19 110:9 203:22 342:20 364:6,10,18 367:10 subjective 190:7 submit 74:25 332:24 333:10 submitted 332:20 subpoena 27:9 Subscribed 368:15 subsequent 43:2 subsequently 257:17 subset 95:23 subsidiary 14:17 100:17 224:21 subspecies 240:18 substance 40:15 40:22 41:7 44:8,9 57:25 69:3,9 70:3,17 70:25 123:13 276:18 297:17	364:20 368:7 substances 23:25 43:14 substantially 346:16 substitution 90:15 succession 275:18 suffice 27:6 353:6 sufficient 80:14 84:4 190:5 267:19,20 270:14 sufficiently 129:24 237:12 238:16 suggest 32:9 98:3 100:10 175:11 227:18 262:1 suggestion 155:9 suggestions 31:24 33:17 suggests 83:4 112:14 174:7 250:8 Suite 2:8 3:7 summaries 20:25 summer 45:22 sunglasses 290:10 superset 181:17 supervised 360:5 supplement 141:21 146:10 226:18 supplemental 5:4 88:16 support 100:22 202:15 213:24 252:5 253:17 supported	180:23 244:4 suppose 254:24 supposed 25:6 230:15 307:10 supposedly 272:10 supposition 100:23 157:7,9 sure 13:18 21:15 21:19 57:18 68:13 81:24 92:3,25 124:2 141:21 146:9 186:20 202:6 218:23 249:9 250:18 264:2 268:4 282:9 307:16 309:25 317:8 327:22 355:8 surface 348:24 survey 72:21 73:1 82:2 333:23 334:16 336:24 Survey's 333:19 Susan 2:20 9:6 Susan.Sharko... 2:20 suspect 162:11 249:1 suspected 173:19 209:24 SUTCLIFFE 2:15 switch 25:16 swivel 196:14,17 sworn 9:18 366:5 368:15 symmet 208:15 symmetrical 208:14,16 synchrotron 52:9 synthesize 124:10 system 169:2
---	--	--	--	--

337:7 systematic 109:21	261:8 285:11 286:24 287:1,2 309:1 331:11 366:8	190:23 191:22 192:1,12,19,20 200:19 206:19 206:23,25	99:23 100:11 139:15 231:12 260:12 262:22 364:7	technical 5:20 298:10 Technically 354:12
T	takes 41:6,17	207:5,8 212:3	talk 11:3,4	technique 68:22
T 3:1	42:1 52:7	212:5,12,16	64:14 65:8	72:12 124:9
table 79:1 84:9	53:22 276:9	214:9,11 215:2	83:8 133:11	195:24 266:24
90:6,6 95:3	277:21	215:9 216:16	143:2 184:17	267:1,20,24,24
147:23 226:21	talc 17:15,19	216:21 217:5	189:3,9 359:8	268:18 270:6
227:7 262:9,10	18:4 19:1,7	220:23,24	359:19 360:8	272:13 308:3
272:6,15	20:5 44:13,19	221:3,12,14	360:23	316:25 361:11
273:20 336:20	44:19 47:17	224:22,23	talked 181:7	techniques 62:8
337:1 338:4	49:11,24 50:2	225:6 226:11	217:21 218:20	72:4,8 73:2
345:21 346:4,7	50:7 56:8,22	226:19 227:22	330:14	146:18 195:11
346:12	64:7 65:4,21	230:23 231:4	talking 93:3	198:21 220:11
tables 326:1,13	66:4,6 69:18	231:11,21	116:15 123:22	220:13 267:4
326:25 327:6	70:16,17 76:21	232:9,21,23	137:10 161:21	267:14 268:2
tabs 227:13	77:3,16,16	233:8,22 241:7	181:18 193:7	269:21 270:11
tabulated	87:5,15,16,17	241:7,10 248:7	203:6 206:8	336:6 341:3
274:13	87:25 88:4	248:11 254:7,9	210:8 230:22	361:3,22 362:3
take 7:23 22:21	96:19,21 97:3	255:14,15	242:19 272:15	362:21,25
26:6,9 33:25	97:8,13,21	256:21 257:13	275:15 295:23	363:6 364:13
38:12 40:22	98:9,17 99:9	258:5 259:3	299:20 324:19	365:3
41:19 44:11	100:3,16	263:18,24	351:14 362:25	technology 85:1
57:14 60:18	101:18,25	264:23 268:5	talks 54:22,23	348:12
86:24 96:8	103:15,18	268:19 269:1	54:24 65:24	Tecum 4:12
98:24 102:2	104:5,19	269:12,22	73:6 108:5	tell 9:19 22:22
105:9 112:4	105:11 106:23	270:8,15 275:4	119:22 126:13	37:21 61:12
118:16,22	107:2,9 108:1	277:11 286:5,7	126:22 175:20	66:24 72:5,9
119:16 120:17	108:21 112:8	286:20 287:6	189:4,6 302:12	73:14 82:19
126:20 135:25	112:15,18	289:22 290:1,3	303:4	138:16 151:21
157:16 162:4	113:7,22,24	297:13 301:3,5	task 161:3 276:8	154:8 180:15
162:17 186:2,4	114:3,4,9,16	301:14,20,21	tasked 170:17	181:15 183:5
189:14 200:24	114:22 115:1	302:21 310:4,6	tasks 38:6	197:1 201:19
203:15 204:23	115:12 118:15	310:7,16,18	taught 222:10	212:25 219:2,6
211:24 227:13	122:8 123:17	341:16,24	222:15 277:16	220:5,14 228:4
231:23 256:3	132:18 158:14	342:7,13,20,24	295:3 358:8	233:4 239:22
257:22 273:13	159:7 163:19	351:8,15,22	359:13	262:22 267:5
277:18 286:15	163:20,24,25	353:9 364:14	teach 63:10	268:8,9,11,14
300:6 308:5	164:5,7,13,14	365:4	167:20 181:12	291:19 293:22
309:11 345:9	164:15 166:24	talc-containing	208:21 222:1,3	302:8 362:6
357:15 359:17	167:5,9 170:4	123:18	222:6,12	telling 91:10
360:12	173:1,14,24	talcs 5:7 101:13	277:15	283:25 305:14
taken 10:6 13:17	174:1,4,12	102:22 174:8	teaching 45:23	tells 103:6 108:4
19:21 23:14,19	175:24 180:18	174:17	294:24 295:5	119:15 182:19
24:3,5,6 103:1	182:12,12,24	talcum 1:3 8:9	360:17	196:24 199:23
228:19 245:24	183:3,6,7	62:11 65:14	Tech 358:7	269:4 335:17

TEM 39:18 40:16 41:10 50:17 51:1 52:19,21 58:1 67:9 71:20 80:4 118:1,10 119:7,18 121:5 126:16,16,17 127:1,22 130:17 152:14 196:15 247:17 306:4 325:18 331:18 332:5 351:13,16 352:2 353:11 359:21 360:1,7 360:13,18 ten 52:5 120:9 221:5 272:1 276:24 277:7 353:4 365:6 tendency 111:4 tensile 78:24 79:12,17,19 80:3,9,19 81:3 81:7,10,21 82:1,5 85:21 86:19 193:16 194:8 335:5,13 335:18 336:7 336:10 337:19 338:11,14 339:9,11,25 340:8,10,23 341:4 343:23 344:7,22 345:13,15,23 346:5,6,8,17 347:1,7 term 47:5 111:24 184:13 184:16 234:9 240:22 312:15 325:8 terminology 225:15 240:10 312:11 326:2	terms 38:22 39:4 77:12 95:6 105:7 164:12 236:17 264:17 276:8,9 277:21 278:22 316:23 349:25 362:24 test 17:15,19 39:6,7 80:19 115:12 123:5,9 123:13 133:5 170:2 243:24 248:6 251:20 269:13,16,24 270:4 272:10 272:11 317:21 tested 48:4 50:1 77:15 98:1,3 100:18 124:4 217:8 252:12 253:6 testified 10:8 24:9 74:3 testify 15:13 34:15 366:5 testifying 10:14 testimony 18:6 18:10 19:15,20 20:4,12,17 21:1 23:13,18 23:23 24:18 82:25 120:24 160:20 366:8 testing 18:1 23:12 49:1 50:7 61:15 69:17 76:21 77:2 86:14 102:15 104:15 104:18 105:11 107:2 113:6 115:15 157:10 159:7 160:10 169:22 171:20 182:13 228:3 232:8,13,18,20	233:22 234:2 261:22,23 264:23 297:12 316:19 318:21 353:17 tests 70:23 71:2 160:21 318:6 356:3 text 319:6 textbook 46:7 92:16 148:10 151:25 152:5 167:11 201:15 344:15 356:5 textbooks 120:5 Thank 213:8 280:21 363:25 Thanks 234:19 theoretical 209:23 theses 360:6 they'd 159:20 thick 186:7 thickness 304:6 306:18 thicknesses 301:8,21 302:1 304:15 305:11 306:25 307:12 thin 294:8 297:5 thing 39:4 69:7 70:1 107:1 152:6 168:4 170:16 171:3 202:8 262:4 271:8,9 277:24 283:18 295:2 332:5 345:3 things 59:19 72:15,24 108:5 152:8 167:17 171:11 228:17 260:15 298:3 298:10 325:19 338:12 361:17 think 22:2 42:15 46:21 57:10	58:18 75:15,23 77:25 80:18 83:14 89:6 99:23 117:11 151:7 190:6 202:9,19 219:9 223:4 233:19 235:13 262:3 270:10 276:8,9 277:5,21,22 280:3 283:7 295:3 296:10 297:10 300:12 304:18 313:4 313:11 325:7 326:17 352:21 362:19 thinks 41:21 third 117:13 124:25 195:19 244:13 247:16 282:3 thirty 367:15 THOMAS 3:1 thought 57:3,11 75:12,21 76:4 168:16 347:19 363:23 thousand 338:14,16 thousands 51:24 130:8 292:5,10 292:16 294:6 threaten 37:12 three 41:8,11 58:20,25 68:25 102:17 140:11 165:9 178:12 201:12 206:13 221:4 227:1 248:7 340:15 three-dimensi... 178:21,25 196:15 199:24 201:11 210:21 212:23 244:10 threshold	340:23 tilt 178:19 208:13 209:8 209:21 212:15 tilted 41:13 207:10,14 212:6 tilting 207:17 208:8,25 212:4 244:17 time 8:5 13:23 15:22 34:1 36:7,18 41:17 41:21 42:1,24 45:20 46:6,17 54:3,7,11 58:11 60:2,18 60:19,23 61:22 66:20 68:10,14 73:14 80:14 86:2,24 121:22 121:25 144:20 146:11 154:7 156:12 157:17 161:6,8,12 162:17,18 177:10 200:15 213:9,13 224:5 229:10 237:21 245:19,20 248:4 249:4,24 252:21 253:6 256:5,10,25 259:14 272:22 272:23 273:5 275:20 276:5 276:14,19,21 277:18,21,24 278:2,6 295:7 295:11 308:7 308:10 310:2 326:4 334:24 339:15 340:16 343:4,9,12 348:23 349:15 351:20 352:24 353:3 357:13
---	--	---	---	--

359:16 364:22	115:11,19,22	145:13 151:2	14:1 21:14	two-thirds
365:13 366:8	120:16 259:5	158:13 159:22	28:10	337:20
time-honored	265:12,20,25	173:16,20,23	Tucson 349:20	twofold 304:19
308:3	266:6 336:12	174:20,21,24	TUESDAY 1:8	type 51:9 79:15
times 1:14 8:7	361:14,22	175:3 176:16	turn 78:18	145:15 158:2,2
17:12 24:9	top 46:22 177:23	176:18 179:8	130:19 172:22	315:16 346:7
63:7 235:21	272:7,16	179:16,20	204:4,8 206:4	typed 88:22
280:20 294:25	273:20 311:21	180:17 185:2,8	235:9 309:24	types 51:5 89:17
295:3 296:12	topic 57:2 80:15	190:19 193:5	336:20	97:7,8 129:25
296:18,24	347:7	217:14 245:15	turned 289:20	132:8 144:16
347:13 358:9	topics 25:8	245:19 247:3	turning 211:3	345:24
tiny 143:22	360:19	247:20 248:14	226:16	typical 273:5
195:14	total 29:20 36:2	250:10,24	two 52:1 64:8	360:19
tissue 144:17	205:12 249:15	251:4,10,15,18	69:13 70:8	typically 97:3
146:3 154:2	302:15 340:15	252:9 253:24	72:8,18 89:16	279:16
title 67:20,22	350:2,7,10	255:11 319:15	90:16 120:12	typo 299:22
101:11,15	toxicologist 44:3	337:24 338:19	136:14 153:15	
136:9 144:20	trace 100:18	339:5,10	153:19,22	U
154:21,24	trained 67:1	345:16 346:16	159:3 171:11	ubiquitous
155:2 351:21	266:2	347:1	180:13 199:13	225:23 335:14
351:21	training 113:19	trial 20:17 21:1	199:17,24	ubiquitously
tlocke@seyfar...	transactions	160:19	200:1,19 201:5	120:5
3:2	173:8	tried 17:11,12	202:1,25	Uh-huh 35:14
TM7024 6:16	transcript 366:7	trip 46:4	203:10,19,25	116:21 150:2
today 8:10 13:17	367:16,17	true 71:21 72:13	205:1 206:13	190:16 202:23
15:13 80:17	transcription	72:17,24 111:6	207:19 208:15	206:15 209:15
87:2 219:14	368:5	126:14 128:22	209:22 211:15	236:10 245:9
220:5,22 223:3	transmission	129:3 133:20	212:25 227:1,2	291:2 313:15
309:2 343:23	4:21 39:13,25	205:9 212:10	228:1 233:7,20	319:7 337:2,9
353:25 354:6	117:3 124:15	212:14 236:2	241:17 243:20	349:2
356:7,14,23	186:4 196:2	244:20 249:6	244:1 257:7,11	ultimate 354:17
357:4 363:1	207:16 209:1	251:7 252:8	259:2,12 260:5	ultimately 22:7
today's 8:4	266:15 351:8	283:18 285:20	261:3,8 264:12	170:4 173:7
365:14	351:23	286:14 287:14	269:13,15	un 306:4
told 21:24	treat 267:15	288:25 305:6	271:3,11 276:4	unbiased 172:9
273:10 296:2	297:21	322:7 326:7	277:1,7,11	unclear 104:11
Tom 9:11	treated 90:19	338:13 344:6	286:15,16,23	104:14,17
tool 85:5,10	91:6 93:23	truth 9:19,19,20	289:1,20	259:21 307:7
116:18 181:24	95:10,22	366:5,6,6	306:11,13	313:6 328:12
266:7,13,18,22	trees 89:5	try 153:18	339:10 346:2	328:13
316:24 359:15	tremolite 5:12	168:22 219:10	354:8,10,10	undergraduate
toolkit 222:23	79:3 89:18,19	trying 132:15	359:23 361:3	359:11 360:6
tools 57:23	91:20 112:8,20	136:22 149:17	361:13	undergraduat...
64:15 65:1,19	115:2 124:7	186:21 209:8	two-dimensio...	167:15
66:10,11,25	130:25 134:23	242:14 255:2	119:10 178:2	underlie 27:25
67:1 71:20	135:6 140:16	276:9	208:14,16	underlies
84:14 85:8	144:4,21	Tucker 3:6 9:9	318:12 331:19	230:10

underlying 361:4	unopened 104:18	334:25 335:24	350:13	100:1,3,13,16
understand 82:2	Unparalleled	352:23 359:13	varieties 131:1	102:17 158:14
83:12 99:2	6:13 344:17	360:1,7 361:3	173:23 344:24	159:8 164:20
100:13 171:25	unredacted	361:17,22	345:23 362:13	166:23 167:4,9
230:8 236:22	38:10	363:6 364:13	variety 71:12	170:5,10 173:1
246:10 266:4	unregulated	useful 11:23	164:1 173:15	173:15 174:17
324:15	306:2	65:7,12 84:12	various 8:15	174:21 175:21
understanding	unrelated 58:6	85:5 127:19	10:3 25:8 40:2	180:18 190:23
14:5 15:10	unreliable 306:6	172:11 206:18	41:14,18 50:17	191:2,19,21,25
24:24 25:5	unreproducible	230:10 236:18	51:5 101:24	192:12,16
27:7,12 45:15	272:14	238:10 264:14	103:14 140:7	214:10 215:2,9
68:3 75:9 87:4	unspecified	266:8,13,18	144:16 166:3	216:15 221:12
87:23 88:4	234:9 236:17	267:1,24	304:7 344:23	227:20 230:24
103:19 134:7	306:1	268:18,22,24	345:23 346:7	231:11,21
157:4 164:21	unsuccessful	305:19 325:14	360:19	241:6,11
168:7 169:10	323:24	useless 235:24	vary 255:12	245:18 247:1
172:24 224:15	unusual 272:13	236:15	varying 181:4	249:16,21
230:14 237:10	updated 27:14	uses 181:19	vast 243:21	250:13,14
267:9,11 273:4	27:19	182:17 200:5	vehicle 162:7	251:1,12,23
273:16 341:12	use 17:2 26:23	264:14 265:21	163:8	252:11 254:17
understood 83:5	47:4,5,9,15	USGS 6:12	verbatim 318:24	255:24 256:1
undertake	57:24 60:12	334:11,20	366:7	Vermont's
195:20	62:7 63:7,11	344:1,4	verifiable 240:3	175:21
undertaken	64:15 65:2,20	usually 117:25	verification	Vermont-sour...
58:4 72:23	65:24 66:10,25	260:6 277:24	201:22 205:3	220:23 248:7
326:6	67:1,9 68:22	279:3 319:17	205:10 218:9	248:11 254:9
undertaking	73:2 78:9 81:6	Utah 48:20	219:24 235:6	255:15
166:14	85:23 89:3	utilize 326:9	236:8 237:14	version 38:11
unfeasible	106:20,22	V	239:5 241:15	versions 134:18
241:13	107:16,18	V 2:16 3:14	241:24 242:12	versus 87:16,17
Union 3:9 9:10	108:9 115:11	vague 110:17	242:20 243:19	187:13 212:3
unit 81:5,18,19	115:20,23	219:10 264:17	Verifications	245:15,20
236:15	116:3,13,18,19	Vaguely 45:12	6:5	247:20 248:14
United 1:1 47:21	116:25 120:4	valent 60:4	verified 238:25	251:22 252:10
93:24 334:17	120:17,19	valid 57:1 129:1	verify 86:13	253:24 254:10
348:7 350:19	132:12 136:13	validate 137:13	237:12	272:23 275:2
units 235:19	139:25 146:21	value 235:7	vermiculite 45:2	275:24 278:4
236:14 238:11	184:14 216:3,8	239:23 256:1	58:22 59:15	293:1 295:9
239:25 344:1,3	219:5 222:4,25	values 219:23	66:7 74:6	317:25
universe 166:22	237:17 239:23	238:3 239:7	123:5	vibrating 290:8
186:22	240:22 256:23	van 46:3	vermiculite-fi...	victim 8:15 10:4
University	263:22 266:3	Vanderbilt	123:9	74:15
52:12 144:6	271:15 279:10	310:4,18	Vermont 17:20	Victor 144:5
174:6	283:3 288:17	variable 189:12	18:3 19:1,8	videographer
unknown 105:6	298:18 307:4	variation 240:22	87:10,16 88:1	7:25 8:2 9:13
125:6	325:13,18	varies 235:2	88:5 96:19	25:17 60:19,22
			97:11 99:20,24	92:25 121:20

121:24 161:7	W	95:21 106:14	weeks 295:4	16:12 19:11
161:11 213:9	W.R 74:4	111:23 112:2	weight 182:1	20:18 21:23
213:12 256:5,8	122:17	112:17 114:15	274:6 298:22	22:8 24:25
308:6,9 343:6	wait 150:16	129:22 134:7	306:2	25:3 26:5 27:4
343:9,12	203:5 223:20	142:8 152:12	weights 304:8	28:11 30:13,22
347:16 355:6	Walter 5:22 6:1	163:16 175:11	weird 345:18	31:10 32:4
365:10	6:3 221:17	178:7,20	welcome 11:4	33:23 37:2,9
videotape	222:10 224:10	180:16 181:8	well-accepted	38:7 41:2
347:15	258:14	185:15,25	194:13	44:22 45:12,17
videotaped 1:12	want 26:4,8 28:4	193:9,23 195:5	well-calibrated	46:16 48:14
4:11 8:6	51:8 55:12,15	200:14 213:2	53:21	62:18 63:5
videotapes	64:20 83:14	229:23 234:6	well-recognized	68:7 71:9,25
10:13	141:20 169:17	237:3 239:23	299:7	73:20,24 74:9
view 79:5 82:16	171:25 172:2	239:24 254:22	well-respected	74:19 75:12
129:21 178:21	172:10 176:21	270:20 278:19	146:25 221:20	76:16 77:21
266:22,24	189:1 190:10	285:8 289:17	Wellesley 42:22	78:7 80:22
269:12 278:17	220:14 223:20	290:7,17 291:5	43:3	82:12 83:3,24
283:15	224:3 228:22	297:21 316:21	went 87:25	84:16 85:22
viewed 119:11	229:4,14	317:23 318:8	113:7 165:16	87:8 88:9 89:8
279:4	230:14 231:2	319:1,4 325:21	220:24 229:10	90:22 91:10
viewing 178:12	258:16 259:24	331:23 332:7	weren't 211:7	93:4,9 94:3
viewpoints	260:15,21	332:18 337:20	220:12 230:4	95:14 96:3,13
196:10	261:7,11,14	341:13	287:2	96:23 97:5,16
views 75:4	263:1,10,12,17	ways 55:1 94:20	West 2:17 174:9	97:24 98:15
Virta 334:7,11	268:20 300:3	289:20	western 140:14	99:13 100:7,21
334:13 336:23	302:8 309:16	we'll 7:20,21,22	When's 68:14	103:9,21
344:16	343:8 355:6	25:18 33:25	WI 227:15	104:10 105:2
virtually 250:22	wanted 307:23	38:12 57:14	wide 71:12	105:16 106:18
visible 174:20	Washington 2:9	64:14 200:25	164:1 265:2,13	108:24 109:7
visual 152:9	3:3 140:13	243:4 306:12	304:14 305:10	110:1,19
213:22 215:24	wasn't 24:22	316:20	306:24 307:12	112:10,23
231:10 262:10	68:19 81:12	we're 61:2 68:11	wider 107:10	113:12 114:7
262:13,15,16	103:24 106:1	149:16 213:17	width 184:2	114:20 115:4
262:16 305:23	169:21 225:19	229:19 256:12	187:13 327:2	118:21 119:20
305:25 359:21	225:22 273:23	258:10 282:9	328:3	121:1 126:25
360:2	342:7,7	299:15 343:18	winchite 89:20	132:3,25
visually 118:19	waste 177:3,18	we've 7:8,13	319:17	135:12 141:20
178:14 186:8	wave 283:3,6,18	26:5 57:12	Windsor 100:17	142:22 143:18
325:19	283:21 286:24	89:11 112:3	159:7 174:9	146:8 154:6,24
vocabulary	287:11,21,24	167:15 181:18	224:11,16,20	157:15 158:19
240:9	288:8,18	213:3 221:10	225:14 226:5	159:15 160:4
volcanic 156:10	way 18:9,24	257:7 260:4	227:4,20	160:16 161:1
162:8 163:11	26:21 28:17	267:15 297:10	257:14 260:23	162:15 163:5
volumes 304:3	58:2 70:16	306:8 318:5	wire 346:18	163:23 164:11
voluntarily	79:14 81:20	362:25	witness 7:16	164:25 166:10
232:21	82:5 83:12	Web 110:2	9:15 10:21	167:2 168:11
		weekly 54:8	11:6,19 14:7	169:13 170:7

171:1,23 173:4	350:6 351:18	232:7 255:3	writer 174:22	233:14
175:16 176:9	352:9 353:13	265:7,16	writes 111:3	
177:13 178:17	354:18 355:9	332:18 333:20	writing 31:8,24	Y
179:10 180:4	355:18 357:10	334:20 342:21	38:15,17,17	Yamate 4:24
180:20 182:3	367:1	354:4 356:14	59:1 75:20	54:22,22 61:17
182:16 187:8	witnesses 18:8	356:22	173:12 225:14	67:18 68:4,12
188:9 189:24	wollastonite	worked 16:9,13	written 19:24	68:15,24 69:25
191:24 194:22	66:6	20:14 51:22	33:17 43:19	70:12 115:17
197:18 202:6	wonder 228:15	52:4 53:7,24	67:18 107:20	126:2 127:4,25
204:10 205:24	wondering	68:5 74:15	119:14 120:1,4	135:15,19
212:8 213:20	163:1	76:9 358:15	147:8 167:12	136:6 137:17
214:13 215:7	wonders 262:19	worker 174:6	167:14 177:11	137:25 142:16
216:3,24	word 17:7 32:24	working 13:15	201:9 309:6	199:16 200:18
217:24 219:20	39:24 41:20	14:9,13 29:3	345:4 348:5	200:22 201:2
220:10 221:9	50:11 60:10	36:8 174:15	358:10 362:19	202:1,13,18
225:1 226:2	73:10 183:12	245:12	wrong 107:9	203:3,9,14,24
227:24 229:3	216:3,10	works 21:15	150:20 175:12	204:9 244:2,5
229:18 230:13	239:20 262:13	24:19 74:14	wrote 89:7	244:5 260:3
232:3 233:2,12	262:24 298:7	330:10	125:9 161:23	261:2 264:11
234:1,17	words 50:12	worksheets	162:23 225:20	336:4
235:10 238:22	149:16 151:18	237:14	310:2 321:4	yeah 8:25 30:16
239:17 242:15	152:9 208:15	workshop 45:23	334:11 355:3	62:21 64:22
242:18 243:6	238:7 272:8	46:1,2	wrought 346:17	120:1,12
244:4 246:16	273:9	world 97:20	347:2	150:18 210:4
246:21 248:19	work 10:17	98:8 113:5	Wunderlich 3:6	213:6 223:16
250:2 251:7,25	14:20 15:17,25	162:13 168:3	9:8,9	223:18 282:2
252:14 253:11	19:22 20:18	170:21 191:15	Wylie 19:16,17	282:13 284:25
257:22 258:18	21:5,23 23:3	192:3 248:8	83:7 330:13	288:3 299:21
259:8 260:25	28:11,17,19	Worldwide 6:15	332:14 334:7	300:6,11
261:20 263:8	29:12,18 30:6	351:6	Wylie's 330:15	309:24,25
264:1 270:10	30:9,18,22	worth 40:25		313:11 315:9
281:14 282:15	32:1,10 33:9	worthy 333:4	X	345:11 354:18
282:22 284:8	33:18,18,20	wouldn't 36:10	X 188:24	354:20
284:10,21,25	34:5,10,21,21	110:19 117:23	X-ray 39:3	year 23:15,20
285:22 294:16	35:23,25 36:21	124:8,12 149:6	50:18,19 56:13	24:3,5 58:3
296:9 303:2	36:24 37:8,12	149:14 183:4	128:1,14	93:4 349:5
308:17 310:3	38:7 43:18	198:7 211:25	134:22 138:19	358:6 359:12
310:11,20	52:8,10,12	225:24 230:5	138:25 145:3	365:2
311:5 312:4,14	66:21,22 74:1	248:12 251:16	145:12 181:9	yearly 54:12
314:24 318:3	74:11,20,23	286:19 287:7	181:14,15,17	years 17:1 42:15
323:15 327:21	75:25 76:2	Wow 217:24	181:23 182:7	51:7 52:5
329:10 332:4	77:18 78:1,11	wrapping-up	182:10,16,20	53:17,19 62:8
334:2,7,22	109:4 122:4,8	306:9	183:4,8 200:15	73:22 75:7,10
339:2 341:20	122:14,17,20	write 16:21	360:18	145:21 164:23
342:3,24	122:23 123:2	145:1 173:13	Xerox 225:22	294:24 308:4
344:11 347:25	169:4,6 174:4	202:9 213:20	XRD 56:14	311:20 345:4
348:10,16	205:22 212:22	214:5,6 355:10	181:9,16 233:5	346:14 348:3,5

348:7,25 349:1 358:8 359:11 yep 150:22 234:17 280:13 282:15,15 303:2 309:13 309:14 yesterday 7:4 16:4 27:8 36:18,20 York 1:15,15 2:17,17 8:8,8 44:19 48:19,20 191:17 310:7	107:6 108:10 117:7 123:21 132:3 133:21 137:9 144:24 146:4 150:14 217:17 218:22 223:25 226:19 226:21 227:7 262:9 284:16 300:24 315:21 319:20 320:5 320:14,20,23 322:6,10,16,21 323:21 324:2,7 325:1 329:8,13 329:16 1,000 241:2,5 1.610 108:17 1:22 161:13 10 5:7 78:19 79:10,19 80:10 80:20 85:17 100:24 188:3 204:13 205:12 205:17 245:21 247:9,12 249:20,25 251:17 271:15 273:14 284:17 288:21 290:13 290:16,17 291:4,12 10:05 60:20,21 10:21 60:23 100 3:7 5:7 190:4 219:21 251:14 361:25 1001 2:8 10019 2:17 11 5:9 35:13 79:10 139:20 284:17 288:20 288:21 309:23 336:20 337:1 11:31 121:22,23 11:47 122:1 12 5:12 143:25	159:2 280:3 284:17 288:2 288:20,21 12/11/2018 281:3 12:37 161:9,10 12:40 159:2 125,000 349:5 127 2:12 13 5:13 147:19 150:1 280:22 281:21 284:15 284:17,18 288:21 289:9 321:21 324:1 326:18 13,000 303:14 13.0 352:2 13.34 321:12 329:1 13794 4:19 61:16 67:6 139 5:9 13th 284:18 289:7 14 4:11 5:15 148:20,23 337:1 14.2-3-4 302:11 14.2.3 303:10,19 303:22 305:7 306:22 14.2.3.4 300:16 140 7:6 143 5:11 147 5:13 148 5:14 15 5:16 152:20 152:23,24 159:25 273:14 276:1 277:13 150,000 36:3 152 5:16 15200 347:13 16 5:19 172:12 172:15,17,20 172:23 173:11	176:6 16-2738 1:4 16.3 302:25 303:1 161 12:12 16th 88:21 17 5:21 172:12 172:16,18,21 176:24 179:14 172 5:18,20 179 253:24 18 5:23 29:19,25 30:18 190:12 190:14,15 223:8,13,15 224:1 226:16 231:7,9 18,500 29:21 35:22 180 242:7 243:9 182 5:14 148:24 19 6:1 29:19,24 30:17 147:24 223:8,15,24,24 223:25 231:7,9 256:15 257:5 19.21 150:19 1912 148:3 1919 148:3 1920 150:8 1950s 339:20 1960s 5:3 1970s 225:19 231:6 1975 5:23 6:1,3 223:25 226:19 228:14 258:15 259:6 263:15 1976 223:18 224:9 1977 292:25 311:10 1978 359:11 1980s 93:8 1984 61:17 67:19 201:2 1989 172:25	1991 101:5 1992 5:19 1996 45:22 1997 147:14 1st 88:25 <hr/> 2 2 1:8 4:3,13 8:4 22:14,18 24:25 28:2 35:11,11 42:15 61:16 65:23,24 69:1 107:7 117:7 134:18 136:18 136:21 137:8 137:10 150:14 172:22 173:11 204:14,17 231:10 257:19 262:10 284:16 300:24 308:16 313:13 332:22 2,000-page 89:4 2.29 313:10,14 314:7 2.5 271:7 2.9 317:7 2:24 213:10,11 2:46 213:14 20 6:4 36:12 145:21 204:12 205:5 223:8,12 223:18,20 224:4,6 225:4 226:17 271:15 290:13,16,17 291:4,12 295:3 295:4 303:13 303:21 315:21 320:5,14,23 322:5,10,15,21 324:2,6 325:1 329:7,12,16 335:19 358:9 360:21 362:20 368:16 200 243:7
--	---	---	---	--

20004 2:9 3:3	222 64:24	230 111:2	155:4,24	4:58 308:7,8
2000s 5:3	222-1 126:10	232-5507 2:9	200:18 203:17	40 17:1 62:8
2002 5:20 144:7	22262 54:23	236 6:5	204:14,18	199:10,13
177:5	65:22 79:13	237 345:1,10	206:6,9 244:2	358:8
2003 6:10	126:9 133:4,22	24 6:3,12 223:18	244:5 249:16	40-year 67:2
290:12	302:4 314:25	224:9 245:7,11	257:19 284:16	400 280:20
2004 147:14	319:13	333:14,17	366:19	401 2:8
2005 334:12	22262-1 4:16	336:23	3,000 365:2	41 203:3,8
2007 150:9	55:4,25 61:16	241 345:22	3:35 256:6,7	359:11
2008 147:24	61:23 62:15,25	243 347:10	3:54 256:10	420 152:19
355:4,12	64:1,4,18,25	24th 223:23	30 46:8 53:17,19	422289 5:21
2010 143:15	66:9,20 86:16	25 4:15 5:19	199:12 351:18	422290 5:21
293:2,5 308:23	126:1,14	6:13 218:13	362:20 367:15	44 202:22
309:3,10	128:22 129:3	245:14 247:2	30,000 35:22	203:16
2012 91:17	130:13 131:19	250:9 343:14	300 48:7 363:17	448 144:25
2016 152:18	182:4 205:19	343:21	363:19	46 271:25
159:24	206:5,16	25,500 35:23	300,000 48:8	463-2400 3:3
2017 35:7,17	211:16 212:1	250 198:22,25	31 40:5	47 272:7,16
247:10 248:6	298:20 299:4	358:10 362:4	314 3:8	273:20 290:25
249:17 250:12	299:12,16	364:1	32 213:19	48 290:11
250:23 251:20	302:5 313:1,10	250-plus 364:2	249:15	489 92:21
293:8 311:11	314:7 319:12	251 363:12	329 6:8	49 278:8 280:7,8
2018 28:16	320:24 322:24	26 6:15 245:11	33 126:21 234:8	280:11 283:14
34:20,22 35:6	324:4,18	245:16,18	234:14,15	290:11
35:6,13,16,19	329:15 336:4	350:23 351:3,5	238:23	4th 28:18
248:10 249:22	22262-2 4:18	352:21,21	333 6:11	
250:23	55:5,25 56:15	269-2343 2:5	334 2:5	5
2019 1:8 8:4	56:19 57:7	27 352:17	34 190:13,15	5 4:18 5:23
24:6 28:19	63:19 64:1,6	27,000 338:21	191:7	60:24 61:10
36:4,8 88:17	64:19,25 65:18	279 6:7	343 6:13	140:7 204:11
106:8 366:19	66:8,20 86:16	28 237:7 322:13	35 164:23	284:17 300:10
202 2:9 3:3	107:23 126:2	289 254:1	240:24 347:10	313:9 314:6
21 6:6 236:4,5	299:10 300:5,7	29 199:10,12,13	35,000 35:24	315:22 319:6
278:10,12	300:23 302:22	249:15 299:4	350 6:15	319:19,20
279:25 280:6	303:12 306:21	299:13,15	357 4:6	320:4,13,22
281:13 284:8	307:9,18 336:4	302:21 313:14	36104 2:5	322:9,20
212 2:18	223 5:22 6:1,3	29th 173:21	363 4:7	323:13,21
218 2:4	2262 298:24	2nd 36:17	37 34:21,24	324:20,23,25
219720 5:19	2262-1 40:9		235:9 241:12	331:25
219722 5:19	23 5:20 6:9	3	39 138:18	5-micron-wide
22 4:13 6:7	177:5 185:2	3 4:15 25:11,20		150:6
279:21,24	186:9,14,15	35:11 56:12	4	5,000 242:16
281:19,19	299:20,22	69:1,12 70:7	4 4:17 8:7 60:24	5,500 60:14
284:20 288:21	300:7,25	70:12 134:18	61:10,23	5:32 308:11
289:8 315:8	308:22 312:20	135:25 136:2	151:13 154:12	5:50 7:4 25:15
319:23 326:17	319:5 329:23	136:12,18	206:5 257:19	50 36:14 298:12
326:23	330:3,3	154:11,17	284:16 336:19	299:6 300:22

348:25 349:1 350:10 50-some 311:20 500 15:22 29:20 198:22,25 506-3742 2:18 51 2:17 298:12 299:6 300:22 52 73:6 526 148:1,5 527 148:2 528 148:2 529 148:2 52nd 2:17 53 245:6 308:15 308:19 312:17 530 148:2 531 150:1 54 245:6 549-7000 2:23 55 245:6 55,000 339:6 56-page 334:23 571-4965 3:8 5727 154:18 58 130:23 59 130:23 5th 24:6 224:2	134:23 62 130:23 63,000 35:25 63102 3:8 64 206:4 211:17 212:1 65 40:10 209:14 210:3 66 336:18 67 345:4 346:14 348:3,7 67-year-old 346:21 68 348:5 6800 339:5 6th 24:6 35:16	250:16 75/25 256:1		
	7	8		
	7 4:23 60:24 61:10 67:14,16 67:17 68:12,24 125:12 126:3 127:7 128:13 128:25 129:11 131:8 137:5,19 139:4 141:18 142:19 146:6 148:9 149:4 151:23 156:3 158:3,4 179:23 202:20,21 217:17 218:22 284:17 331:1 331:15 345:21 346:7 7.2.3 315:9 7.2.3.7.1 315:7 318:17 320:24 324:18 70-odd 205:15 205:16 7024 353:11 72371 324:5 73,000 346:9 732 2:13 747-9003 2:13 75 247:2 250:8	8 5:1 88:11,14 89:10,11 140:8 245:21 254:8 254:13,14,20 254:22 284:17 80-odd 92:5 80s 93:14 877.370.3377 1:23 88 5:1 89,000 346:9		
		9		
6		9 4:5 5:6 92:17 92:20,21 95:4 245:21 254:18 254:19 284:17 310:25 9.17 148:25 9:03 1:15 8:5 917.591.5672 1:23 92 5:5 94 326:8 973 2:23 975 3:2 9th 2:8		
6 4:20 60:24 61:10 66:18,19 140:7,11 154:12 157:19 157:24 284:17 330:25 6,000 338:25 6:13 343:10 6:14 343:11 6:22 343:13 6:45 365:13,16 60 4:16,18,19,22 130:23 600 2:22 3:7 607 147:12 240:11 61 130:23				

Exhibit 92

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX

**Response to the November 2005 National Stone, Sand & Gravel Association
Report Prepared by the R.J. Lee Group, Inc
“Evaluation of EPA’s Analytical Data from the El Dorado Hills Asbestos
Evaluation Project”**

April 20, 2006



United States Environmental Protection Agency Region 9
Response to the November 2005 National Stone, Sand & Gravel Association report
prepared by the R.J. Lee Group, Inc:
“Evaluation of EPA’s Analytical Data from the El Dorado Hills
Asbestos Evaluation Project”

This document constitutes the United States Environmental Protection Agency Region 9 (EPA Region 9) response to the major findings and conclusions of the National Stone, Sand & Gravel Association report “Evaluation of EPA’s Analytical Data from the El Dorado Hills Asbestos Evaluation Project” prepared by the R. J. Lee Group (R. J. Lee Report). A more detailed analysis will be completed after additional information is received from the R. J. Lee Group and the National Stone, Sand & Gravel Association,¹ and the United States Geological Survey (USGS).

The R. J. Lee Report draws conclusions that are contradicted by the El Dorado Hills data and by generally accepted scientific principles for measuring asbestos exposure.

Overview

The R. J. Lee Group review of the EPA data was contracted by the National Stone, Sand & Gravel Association. The El Dorado County Office of Education funded the three reviewers who wrote letters in support of the R. J. Lee Report and whose reviews are included in this response.

The EPA Region 9 El Dorado Hills Naturally Occurring Asbestos Exposure Assessment was designed to measure the exposures to asbestos fibers, if any, that resulted from sports and play activities that disturbed dust and soil. EPA Region 9 adhered to accepted EPA standards for sampling and analysis, including rigorous quality assurance/quality control, and to the standard methodologies of EPA exposure and risk assessment.

The R. J. Lee Report Criticizes EPA Region 9 for Using Established Scientific and Public Health Protocols - In assessing naturally occurring asbestos exposures in El Dorado Hills, EPA evaluated asbestos exposures using the PCME (phase contrast microscopy equivalent) asbestos fiber size classification. The PCME classification was used because human epidemiological studies, which form the basis of knowledge of asbestos health effects, measured asbestos fiber concentrations using phase contrast microscopy (PCM) analytical methods. PCME is the standard term for fibers counted by more modern analytical methods that are of equivalent size to those fibers that would be seen by PCM analysis, and includes fibers with a length to width aspect ratio of 3 to 1 or greater. EPA considered PCME fibers in our analysis of the El Dorado data to be consistent with the existing health databases and risk assessment

¹On March 9, 2006, EPA Region 9 sent a letter to the R.J. Lee Group and the National Stone, Sand, & Gravel Association asking for additional information to support the findings and conclusions of the R.J. Lee Report.

procedures used by EPA, California EPA (Cal/EPA), the World Health Organization, and other federal agencies and international organizations. This approach was rejected by the R.J. Lee Group, which instead advocates use of asbestos fiber definitions which are not health based or supported by the majority of experts in the health community, and which would not allow comparison to the existing epidemiologic data on asbestos related cancers.

The R. J. Lee Report Claims that EPA Region 9 Misapplied Fiber Counting Protocols - The R. J. Lee Report claims that EPA Region 9 inflated the fiber counts in the El Dorado Hills air data by misapplying the International Standards Organization (ISO) method 10312 (the analytical method used by EPA to analyze the El Dorado air samples) and including PCME structures with a 3 to 1 length to width aspect ratio in our analysis. The R. J. Lee Report maintains that EPA should only have counted structures which met the general 5 to 1 aspect ratio fiber size definition described in the body of the ISO 10312 method. However, Annex C and Annex E of the ISO 10312 method specifically authorize the counting of PCME structures with a 3 to 1 aspect ratio. Another example of misleading information is the R.J. Lee Report's statistical evaluation and resulting conclusions regarding the concentrations of asbestos structures detected in the EPA air samples. All of the established EPA, National Institute of Occupational Safety and Health (NIOSH), and ISO analytical methods require the counting of asbestos bundles, recognizing the significance of bundles to proper characterization of asbestos fiber levels. The R.J. Lee Report did not include asbestos bundles in its analysis of the data, thereby undercounting the number of structures.

The R. J. Lee Report Claims that EPA Region 9 Misidentified Amphibole Minerals - The R. J. Lee Report concludes that EPA misidentified actinolite asbestos fibers in the El Dorado soil samples by using inappropriate extinction angle criteria. The R. J. Lee Group conclusion is contradicted by the National Institute of Standards and Technology (NIST) and the major analytical methods used for analysis of asbestos in soil and bulk samples. The R. J. Lee Report also cites an unpublished 1980 draft report to support its contention that structures found in the EPA air samples are not asbestos, and ignores a subsequent 1981 published report by the same author that actually supports the EPA approach.

The R. J. Lee Report Applies a Geologic Definition rather than a Public Health Definition to Characterize Microscopic Structures - The R. J. Lee Report relies heavily on the geologic distinction between asbestos fibers and cleavage fragments of the same dimensions, with the implication that exposure to cleavage fragments is benign and of little or no health significance. For the purposes of public health assessment and protection, EPA makes no distinction between fibers and cleavage fragments of comparable chemical composition, size, and shape. The EPA Region 9 approach, which is supported by most public health agencies and scientists, as well as the American Thoracic Society, is based on the following: (1) The epidemiologic and health studies underlying EPA and Cal/EPA cancer risk assessment methods were based on exposures to both cleavage fragments and fibers, and were unable to distinguish between the two, (2) The most recent panel of experts to review asbestos risk assessment methods, the 2003 Peer Consultation Panel convened by EPA, concluded that "it is prudent at

this time to conclude equivalent potency [of cleavage fragments and fibers] for cancer,”² (3) No well-designed animal or epidemiological studies have adequately tested the hypothesis that cleavage fragments with the same dimensions as a fiber are benign or that the human body makes any distinction, (4) Studies that purport to show that cleavage fragments are benign are questioned by many asbestos health experts, (5) There are no routine asbestos air analytical methods, including those used by EPA, NIOSH, the Mine Safety and Health Administration (MSHA), the American Society for Testing and Materials (ASTM), and ISO which differentiate between cleavage fragments and crystalline fibers on an individual fiber basis.

The R. J. Lee Report’s “Virtual” Review of EPA Region 9’s Air Samples is Inconsistent with Established Laboratory Practices - The R.J. Lee Group did not have access to EPA’s actual air samples, nor did it collect any air samples of its own. Rather it reviewed limited pictures and spectra data of a small number of EPA’s air samples and drew conclusions based on those representations. Such a virtual review is not consistent with the National Voluntary Laboratory Assurance Program (NVLAP) quality assurance procedures nor the verification methods of the National Institutes of Standards and Technology.

Federal Courts Have Supported EPA - Many of the assertions of the R. J. Lee Report are consistent with positions that the R.J. Lee Group took as an expert witness for W.R. Grace in the Libby, Montana litigation. In this litigation, the written opinions of the District and Appeals courts, while not specifically addressing the opinions of the R.J. Lee Group, rule in favor of EPA and expressly hold that EPA’s experts and science are credible.³

Background

In October 2004, the EPA Region 9 Superfund site assessment program conducted an assessment of exposures to naturally occurring asbestos (NOA) in El Dorado Hills, California. Specifically, EPA Region 9 simulated the sports activities of children and adults at three schools and a community park and, using personal air monitors, measured asbestos levels in the breathing zones of participants. EPA Region 9 also collected samples of ambient air in the area of the sampling at the same time the simulations were conducted to serve as reference samples. The personal activity-based samples were then compared to the reference samples. The Asbestos Hazard Emergency Response Act (AHERA)⁴ regulation Z-test for statistical

²USEPA (U.S. Environmental Protection Agency) (2003). Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk, Final Report. Office of Solid Waste and Emergency Response, Washington D.C. Page viii.

³ See U.S. v. W.R. Grace, 280 F Supp 2d 1149 (2003); U.S. v. W.R. Grace, 429 F. 3d 1224, 1245 (9th Cir. 2005) (Although debate regarding testing methodology and data analysis is “exceedingly complex”, EPA did not ignore accepted scientific principles)

⁴The Asbestos Hazard Emergency Response Act (AHERA) was passed by Congress in 1986 to provide for the inspection and mitigation of asbestos in school buildings. Regulations implementing the Act were promulgated by EPA in 1987.

significance was applied to determine whether there were any statistically significant differences between the personal exposure samples and the ambient reference samples. EPA Region 9 collected over 400 air samples and generated over 7000 data points. All of EPA Region 9's analyses were conducted by accredited laboratories using recognized methods and procedures with strict quality assurance control, including blind performance samples to check analytical accuracy.

Amphibole asbestos, which many health scientists consider to be even more toxic than chrysotile asbestos, was found in almost all the reference and activity-based samples. Of the 29 different sets of activity-based scenario measurements, application of the Z-test determined that personal exposures from 24 scenarios were significantly elevated over the reference samples. Most importantly, the data showed that children and adults participating in sports activities in areas where asbestos occurs naturally in the surface soils, as it does in El Dorado Hills, can be exposed to asbestos fibers of health concern at up to 62 times the corresponding reference levels.

EPA Region 9 released the data from the assessment in May 2005 and held a public meeting in El Dorado Hills that was attended by more than 1000 members of the public. From the outset of the assessment, EPA Region 9 made clear to the community that EPA's only intent was to gather data on potential exposures. The community and the State and local regulatory agencies could then use the information to make decisions about the significance of those exposures and determine appropriate control measures. Both EPA Region 9 and the Agency for Toxic Substances and Disease Registry (ATSDR) have informed the community that exposure levels are a main determinant of the risk of developing asbestos-related cancers and non-cancer diseases, and that reducing the exposures reduces the risk. Consistent with its intent, EPA Region 9 has actively engaged the State and local regulatory agencies to improve naturally occurring asbestos mapping, monitoring, dust control, and regulation. El Dorado County has recently adopted more stringent dust control ordinances.

Detailed Comments on the R. J. Lee Report

R.J. Lee Finding #1: "Based on Mineralogy, Sixty-Three Percent (63%) of the Amphibole Particles Identified as Asbestos Fibers can not be Asbestos."

The R. J. Lee Report argues that there is too much aluminum in 63% of EPA Region 9's identified fibers for the fibers to be asbestiform.⁵ In addition, the remaining 37% (sometimes the Report uses 35%) are not asbestos fibers based on their particle dimensions.

EPA Response

Aluminum - Analysis of the EPA Region 9 El Dorado air samples was performed using the International Standards Organization (ISO) method 10312, a state-of-the-art

⁵Asbestiform: Having the form or structure of asbestos.

Transmission Electron Microscope (TEM)⁶ method with energy dispersive spectroscopy (EDS)⁷ that has strict counting rules and characterizes the dimensions and chemistry of every fiber identified by the microscopist. Identification of fiber type was performed according to the general guidelines of the International Mineralogical Association (IMA) (Leake, 1997)⁸, the international standard for amphibole nomenclature. This same approach for asbestos classification is recommended in the “Research Method for Sampling and Analysis of Fibrous Amphibole in Vermiculite Attic Insulation”, EPA 600/R-04/004, January 2004, and was one of the tools used by Meeker et al (2003)⁹ to determine the composition and morphology of amphiboles from Libby, Montana.

The R. J. Lee Report claims that 63% of the amphibole fibers identified by the EPA laboratory¹⁰ as actinolite asbestos have concentrations of total aluminum that are too high to form asbestos fibers. According to page 2 of the R. J. Lee Report, “Particles with more than 0.3 aluminum atoms pfu [per formula unit] or about 1.5 percent Al_2O_3 cannot form in the asbestos habit due to crystal lattice constraints.” To support its argument, the R. J. Lee Report cites three references. However, on close examination, two of the three references do not agree with the upper threshold limit that the R.J. Lee Group puts on total aluminum content (Leake et al, 1997) (Deer, Howie and Zussman, 1997)¹¹. The third reference (Verkouteren & Wylie, 2000)¹² draws its conclusions on examination of a

⁶Transmission Electron Microscopy (TEM) produces images of a sample by illuminating the sample with an electron beam in a vacuum, and detecting the electrons that are transmitted through the sample.

⁷Energy Dispersive Spectroscopy (EDS) uses measurement of the energy and intensity of X-rays generated when a selected area of a sample is irradiated with an electron beam to identify the mineralogical composition of a structure.

⁸B.E. Leake et al (1997). Nomenclature of Amphibole: Report of the Subcommittee on Amphiboles of the International Mineralogical Association, Commission on New Minerals and Mineral Names. American Mineralogist, Volume 82, pages 1019-1037.

⁹G.P. Meeker et al (2003). The Composition and Morphology of Amphiboles from the Rainy Creek Complex, Near Libby, Montana. American Mineralogist, Volume 88, pages 1955-1969.

¹⁰In this document, the terms “EPA laboratory” and “EPA Region 9 laboratory” refer to the private laboratories that conducted the analysis of the EPA soil and air samples under contract to EPA Region 9.

¹¹W.A. Deer, R.A. Howie, and J. Zussman (1997). Rock-Forming Minerals: Double Chain Silicates, Vol 2, second edition, p 137 - 145.

¹²J.R. Verkouteren and A.G. Wylie (2000). The Tremolite-Actinolite-Ferro-Actinolite Aeries: Systematic Relationships Among Cell Parameters, Composition, Optical Properties, and

small set of fibrous actinolite asbestos samples which the authors partition into asbestos and fibrous “non-asbestos” byssolite using criteria which the IMA specifically recommends against, and which is inconsistent with all standard asbestos analytical methods. Perhaps most important is the fact that all three references agree that it is the IMA criteria which primarily govern the general classification of amphibole type, not the total aluminum content. These references therefore actually support the classification approach taken by the EPA laboratory.

The R.J. Lee Group did not have access to the EPA air samples to conduct their own analyses. Instead, the R.J. Lee Group looked at a limited number of photographs of the recorded EDS spectra. Interferences by other elements in the sample can affect the aluminum total in the spectra. This is especially important because the EPA samples were of air releases from soil, not processed asbestos material. Soils contain non-asbestos mineral and biological particles that can influence element totals in an EDS spectrum, most notably clay particles, which are high in aluminum. The laboratory used by EPA Region 9 identified aluminum-rich actinolite asbestos, by applying the IMA classification guidelines to its direct analysis of the actual sample.¹³

Particle Dimension - As previously stated, the R. J. Lee Report claims that 37% of the fibers counted by EPA in the El Dorado Hills air samples are not asbestos fibers based on their particle dimensions. The report claims that EPA Region 9 inflated the fiber counts by including asbestos structures which do not meet the definition of a fiber as described in ISO 10312. The general ISO 10312 method requires the counting of every asbestos structure with a length to width aspect ratio of 5:1 or greater. As directed by Region 9, the EPA laboratory counted structures with a 3:1 or greater aspect ratio. The R. J. Lee Report states that EPA erred in counting structures with aspect ratios less than 5:1.

Annex C and Annex E of the ISO method clearly authorize the counting of PCME structures with a 3:1 aspect ratio if the data are to be used for exposure or risk assessment purposes, the stated goal of the El Dorado Hills assessment. In fact, the ISO method contains numerous references to PCME fibers. PCME fibers are defined as fibers greater than 5 microns in length, and 0.25 to 3 microns in width with a 3:1 aspect ratio.¹⁴ PCME fibers form the basis for EPA’s IRIS toxicity database and the asbestos risk models of California EPA and other federal and international organizations.¹⁵

Habit, and Evidence of Discontinuities. American Mineralogist, 85, p. 1239 - 1254.

¹³Personal communication with John Harris, Lab/Cor, January 2006.

¹⁴World Health Organization (1986). Environmental Health Criteria 53, International Programme on Chemical Safety, Asbestos and Other Natural Mineral Fibres, section 2.3.2.2.

¹⁵The IRIS asbestos cancer inhalation unit risk, a measure of asbestos cancer potency, is based on the EPA 1986 Airborne Asbestos Health Assessment Update (EPA/600/8-84/003F; 1986). Cal/EPA used a similar approach and data sets to derive its cancer unit risk. Both the IRIS and the Cal/EPA cancer potency values rely on human epidemiological studies that were conducted using phase contrast microscopy (PCM) analytical methods (some were midget

The R.J. Lee Group also manipulates its statistical analysis of the El Dorado Hills air data by ignoring counts of asbestos fiber bundles in its evaluations. Bundles are two or more attached parallel asbestos fibers which can have a significant health impact when they are inhaled and separate into individual fibers. Bundles were counted in the historical epidemiological studies which form the basis of our knowledge of asbestos-related health effects and EPA's IRIS database. **All of the established EPA, NIOSH, and ISO analytical methods require the counting of asbestos bundles, recognizing the significance of bundles to proper characterization of asbestos fiber levels.**

The R. J. Lee Report further states that EPA's data inflated the asbestos fiber count by ignoring the Agency's own "definition" of asbestos. To support this claim, the R.J. Lee Report cites the glossary of "Method for Determination of Asbestos in Bulk Building Materials", EPA 600/R-93/116, 1993, which states, in part, "With the light microscope, the asbestiform habit is generally recognized by the following characteristics: Mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 microns." The building material analytical method is designed to detect commercially processed asbestos in items like floor tiles, roofing felts, paper insulation, paints, and mastics, not naturally occurring asbestos on air filters or in soil samples. To present the 20:1 aspect ratio for commercial grade asbestos as a universal EPA policy, and to advocate its use as an appropriate standard for analyzing air samples of naturally occurring asbestos is inappropriate and contradictory to use of the PCME dimensional criteria as a tool for assessing exposure risk.

The R. J. Lee Report also states that the diffraction pattern analyses produced by the EPA laboratory for the El Dorado Hills air samples demonstrates that the particles identified by the laboratory are not asbestos.¹⁶ The report cites a 1980 unpublished draft study by S.J. Ring to support its conclusion. The R. J. Lee Report does not mention a 1981 published article by the same author which revises the findings such that they no longer support the conclusion of the R. J. Lee Report and, in fact, support the data produced by

impinger data converted to PCM counts) that could not distinguish fibers that were 5 microns in length or less. PCM cannot distinguish between fibers and cleavage fragments. PCM is not as powerful as current Transmission Electron Microscope (TEM) methods (400X vs 20,000X) as TEM can see the thinner/shorter fibers. However, since EPA's (and Cal/EPA's) toxicity database relies on human health studies that used PCM, current EPA risk procedures use the more powerful TEM method but report the PCM equivalent (PCME) fibers and only use the PCME counted fibers in a risk assessment. This is because the IRIS asbestos file specifies that only PCME fiber counts be used with inhalation unit risk for risk calculation. See also the reference cited in footnote 11.

¹⁶Diffraction pattern analyses irradiates a sample with x-rays and then takes an x-ray photograph.

EPA.¹⁷

R.J. Lee Finding #2: “The Laboratory Procedures did not Comply With the NVLAP Quality Assurance Standard.”

The R. J. Lee Report says that the false positive rate in our air samples was 35% when the acceptable limit in the National Voluntary Laboratory Accreditation Program (NVLAP) is 10%.

EPA Response

The laboratories used by EPA Region 9 for analysis of the El Dorado Hills air and soil samples are accredited through the National Voluntary Laboratory Accreditation Program (NVLAP). NVLAP is administered by the National Institute of Standards and Technology, a non-regulatory agency within the U.S. Commerce Department. A large part of the accreditation process involves on-site audits performed by NVLAP-certified inspectors who review laboratory operational and quality assurance compliance parameters, including documentation proving compliance with NVLAP requirements for verification analyses. A laboratory must demonstrate that all analysts reporting data meet the false negative and false positive requirements set forth by NVLAP before an accreditation certificate is issued. To make a determination that a laboratory did not comply with NVLAP verification standards would require a very detailed examination of all laboratory generated raw data, project specific information, such as a site-specific EPA issued Quality Assurance Project Plan, laboratory instrument log books, and other data and information not supplied in an analytical report. Interviews with the laboratory manager, quality assurance manager, and involved analysts are also mandatory to make judgement on a laboratory’s possible non-compliance. The R.J. Lee Report’s conclusion that the EPA laboratory was not in compliance with NVLAP, based on a cursory review of count sheet and other limited data without the in-depth examination detailed above, is therefore invalid and cannot be used to question EPA’s analytical results.

EPA chose NVLAP-accredited laboratories for the El Dorado Hills assessment as a minimum quality requirement. For supplemental quality assurance, the laboratories were subjected to on-site audits performed by EPA’s Quality Assurance Technical Support group, and both laboratories were sent performance evaluation samples prior to analysis of the El Dorado samples. In addition, the laboratory conducting the air sample analysis was sent double blind performance evaluation samples during the sampling event. In all cases, the laboratories successfully identified the amounts and types of asbestos present on the blind samples within acceptable limits. Further, the El Dorado Hills air and soil data were validated by a third party in accordance with standard EPA quality assurance

¹⁷S.J. Ring (1981). Identification of Amphibole Fibers, Including Asbestos, Using Common Electron Diffraction Patterns. In Russell P.A. and Hutchings A.E. (Eds), Electron Microscopy and X-ray Applications to Environmental and Occupational Health Analysis, Vol. 2:175-198, Ann Arbor Science Publ., Inc.

procedures and were found to be acceptable for all uses.

R. J. Lee Finding #3: “The Soil Samples do not Demonstrate the Presence of Amphibole Asbestiform Minerals.”

The R. J. Lee Report states that the actinolite asbestos fibers identified in the El Dorado Hills soil samples contain too much aluminum to be asbestiform and that the extinction angles of the fibers indicate that they are non-fibrous cleavage fragments. The R.J. Lee Group’s analysis of 23 split soil samples from EPA’s October 2004 sampling event found no asbestos in the samples.

EPA Response

Aluminum - The R. J. Lee Report states that the aluminum content of the fibers in the soil samples was too high to be asbestiform actinolite and that it was indicative of non-asbestiform actinolite and another amphibole, hornblende, which contains approximately 10-20% by weight Al_2O_3 (5.3-10.6% by weight aluminum). Both the laboratory performing EPA’s El Dorado soil sample analysis and the laboratory which analyzed the EPA air samples noted significant quantities of hornblende in the samples, but did not count or report those particles as asbestos. Please see the EPA response to Finding #1 for a further discussion of the aluminum issue.

Extinction Angles - The extinction angle of a fiber evaluated by polarized light microscopy is one of many criteria used to identify mineralogical composition. The extinction angle for amphibole asbestos fibers is the difference in degrees between the long axis of the fiber and the angle at which the fiber optically disappears (the polarization direction where the light passing through it becomes “extinct”) when the fiber is rotated under a polarized light microscope. The R.J. Lee Report states that amphibole asbestos fibers have a zero-degree extinction angle and that non-asbestos cleavage fragments have non-zero extinction angles. Therefore, because the EPA soil sample analysis reported extinction angles which, according to the R.J. Lee Group, averaged 12°, the report alleges EPA incorrectly identified cleavage fragments as asbestos fibers.

The R.J. Lee Report’s conclusion regarding extinction angles is contradicted by the National Institute of Standards and Technology (NIST) and the major analytical methods used for analysis of asbestos in soil and bulk samples. NIST certifies and provides Standard Reference Materials (SRM) for laboratory instrument calibration and laboratory accuracy measurement. The NIST Tremolite/Actinolite SRM 1867A is a special set of three samples certified by NIST to be of ultra-high purity tremolite, actinolite, and anthophyllite asbestos and is considered the “gold standard” for asbestos analytical laboratories. The material is rigorously characterized and is accompanied by a six-page document that describes the properties of each sample. It is required that all analytical laboratories accredited by NIST/NVLAP have the material in their possession and that they use it to calibrate their operations and to test their analysts. The NIST SRM

1867A certificate which accompanies the samples of tremolite and actinolite states that the reference tremolite can have an extinction angle of up to $16.6 \pm 0.3^\circ$ and that the actinolite can have an extinction angle of up to $15.9 \pm 0.2^\circ$. When the EPA laboratory processed the NIST actinolite standard in the manner of the El Dorado Hills soil samples, the extinction angles of the fibers in the processed standard sample were consistent with allowed maximum extinction angles for tremolite/actinolite asbestos ($\sim 10^\circ$ to 20°) and the extinction angles of the fibers seen in the EPA soil samples.¹⁸

Further, the laboratory methods of EPA, NIOSH, and other agencies for analysis of asbestos in bulk material all state that tremolite-actinolite asbestos fibers may have zero (parallel) or *non-zero* (inclined or oblique) extinction angles. EPA Method 600/R-93/116¹⁹, the standard method used by all NIST/NVLAP accredited laboratories to test building materials for the presence of asbestos, states in Table 2-2, Optical Properties of Asbestos Fibers, that tremolite-actinolite asbestos has extinction “parallel and oblique (up to 21°).” NIOSH Method 9002²⁰, the method used for analysis of the El Dorado Hills soil samples, states directly that actinolite and tremolite fibers exhibiting inclined extinction are to be considered asbestos. The method further states that “If anisotropic fibers are found (during PLM analysis), rotate the stage to determine the angle of extinction. Except for tremolite-actinolite asbestos which has oblique extinction at 10 - 20° , the other forms of asbestos exhibit parallel extinction... Tremolite may show both parallel and oblique extinction.”²¹

R.J. Lee Finding #4: “The ISO 10312 Analytical Method can not Distinguish Between Asbestos Fibers and Non-Asbestos Cleavage Fragments.”

The R.J. Lee Report states that the ISO 10312 method contains the disclaimer that “The method cannot discriminate between individual fibers of asbestos and non-asbestos analogues of the same amphibole material,” and, therefore, EPA inflated the asbestos air concentrations by counting “cleavage fragments.”

EPA Response

The ISO 10312 method cannot differentiate between fibers and cleavage fragments with

¹⁸M. Bailey (2006). Identification of Asbestiform Tremolite/Actinolite. Naturally Occurring Asbestos Workgroup Meeting Presentation.

¹⁹USEPA (U.S. Environmental Protection Agency) (1993). Method for the Determination of Asbestos in Bulk Building Materials. EPA Method 600/R-93/116.

²⁰NIOSH (National Institute for Occupational Safety and Health) (1992). Asbestos (Bulk) by PLM.. Method 9002 (Issue 2).

²¹NIOSH (National Institute for Occupational Safety and Health) (1992). Asbestos (Bulk) by PLM.. Method 9002 (Issue 2). Qualitative Assessment, Item c, page 4.

the same dimensions and chemical composition. No routine analytical method has a protocol for distinguishing fibers from cleavage fragments on an individual particle basis. Additionally, from a health standpoint, there is no evidence that supports making the distinction.

Cleavage fragment is a geologic term which refers to structures that form when non-fibrous forms of asbestos minerals split along crystallographic planes, as opposed to asbestos fibers which form from crystalline growth. The R.J. Lee Report maintains that there is a toxicological difference between asbestos structures which formed as fiber crystals and fibers which formed by cleavage plane separation. Page 3 of the R.J. Lee Report states that cleavage fragments are “not known to produce asbestos-like disease.” **It is the position of EPA, the U.S. Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry (ATSDR) and National Institute for Occupational Safety and Health (NIOSH), and the American Thoracic Society, among others, that microscopic structures of amphibole and serpentine minerals that are asbestiform and meet the size definition of PCM fibers, should be counted as asbestos, regardless of the manner by which they were formed.** There are four reasons why the health agencies have taken this position: (1) The epidemiologic and health studies underlying EPA, and California EPA, cancer risk assessment methods were based on exposures to both cleavage fragments and fibers, but were unable to distinguish between the two, (2) The most recent panel of experts to review asbestos risk assessment methods, the 2003 Peer Consultation Panel convened by EPA, concluded that “it is prudent at this time to conclude equivalent potency [of cleavage fragments and fibers] for cancer,”²² (3) No well-designed animal or human epidemiological studies have been conducted to date to test the hypothesis that cleavage fragments with the same dimensions of a fiber are benign, or that the human body makes any distinction, and studies that purport to show that cleavage fragments are benign are questioned by many asbestos health experts,²³ (4) There are no routine air analytical methods, including those used by EPA, NIOSH, the Mine Safety and Health Administration (MSHA), the American Society for Testing and Materials (ASTM), and the ISO which differentiate between cleavage fragments and crystalline fibers.

²²USEPA (U.S. Environmental Protection Agency) (2003). Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk, Final Report. Office of Solid Waste and Emergency Response, Washington D.C. Page viii.

²³Both Addison (Addison J, Davies LST. 1990. Analysis of amphibole asbestos in chrysotile and other minerals. Ann Occ Hyg, Apr;34(2):159-75) and members of the U.S. EPA 2003 Peer Consultation panel raised concerns about interpretation of the Davis study (Davis JM, McIntosh C, Miller BG, Niven K. 1991. Variations in the carcinogenicity of tremolite dust samples of differing morphology. Ann NY Acad Sci, Dec;643:473-90), which attempted to compare the toxicity of asbestos fibers and cleavage fragments. These concerns reflected the lack of peer review, use of intra peritoneal injection instead of inhalation exposure, significance of mesotheliomas caused by structures reported as cleavage fragments, purity of the cleavage fragment samples and issues related to fiber dimensions.

In terms of epidemiological data and health outcomes, the cleavage fragment argument is without merit. For the purposes of public health assessment and protection, EPA makes no distinction between fibers and cleavage fragments of comparable chemical composition, size, and shape.

There are no recognized analytical protocols, including those used by EPA, NIOSH, MSHA, ASTM, and ISO, which include criteria to differentiate between cleavage fragments and crystalline fibers. All these methods require that structures which meet their definition of the specific counting rules for an asbestos fiber be counted. The requirements are based on the fact that, in the words of an expert from the United States Geological Survey, “At a microscopic level, distinguishing between these forms on single [asbestos] particles, can be extremely difficult to impossible.”²⁴ As noted above, R.J. Lee made a very similar claim with regard to cleavage fragments as the expert witness for W.R. Grace in the Libby, Montana, Superfund cost recovery litigation. The EPA analytical experts who reviewed the R.J. Lee Group’s testing methodology related to the Libby site found that the R.J. Lee laboratory could not demonstrate any reliable criteria with which to distinguish, at the microscopic level, asbestos cleavage fragments from asbestos fibers of the same size, shape, and composition. The Ninth Circuit Court of Appeals recognized the competing scientific arguments but found that EPA’s position was consistent with the record of evidence and accepted scientific principles.²⁵

R.J. Lee Finding #5: “Applying the Latest Science and Definitional Techniques, the El Dorado Hills Study Shows no Significant Exposure to the Type of Amphibole Asbestos Fiber Connected To Health Risk.”

The R. J. Lee Report claims that the latest science for measuring the risk posed by asbestos is the Berman-Crump Asbestos Risk Assessment Protocol (“Berman-Crump”) which proposes that amphibole asbestos fibers which are more than 10 microns long and less than 0.5 microns wide (protocol fibers) are the most toxic. Of the 2,386 fibers which the R. J. Lee Report states the EPA laboratory identified, the R.J. Lee Report concludes that only 7 fibers meet the “Berman-Crump” definition. Therefore, the R.J. Lee Group maintains that EPA has overstated the risk from exposure to asbestos fibers in El Dorado Hills.

EPA Response

The “Berman-Crump” protocol that the R.J. Lee Report references is in fact a draft EPA method. EPA had the method reviewed by a peer consultation panel in 2003. The panel made a number of important recommendations that must be addressed before the method can be used for EPA risk assessments. A number of important revisions have been made

²⁴G.P. Meeker, USGS, (2002). Review of Expert Report of R.J. Lee.

²⁵U.S. v. W.R. Grace, 429 F.3d at 1245.

to the draft method since 2003, but at this time the method has not been independently peer reviewed. It will not be adopted by EPA as a risk assessment tool unless and until it passes rigorous internal and external peer review.

The expert peer panel has recommended that the fiber size for the draft EPA risk assessment method be adjusted to include fibers greater than 5 microns in length and up to 1.5 microns in width.²⁶ The change is designed to account for lung deposition of fibers that results when fibers are inhaled through the mouth, and not filtered by the nasal passages. The broadening of the fiber definition to include inhalation by “mouth breathers” is especially relevant to the El Dorado Hills data. Our investigation measured personal asbestos exposures of individuals participating in sports activities, where physical exertion would likely increase breathing through the mouth. **The PCME fibers counted in the EPA air samples are actually consistent with the latest science of EPA, as reflected in the recommendations of the peer consultation panel.** In addition, the EPA peer consultation expert panel recommended that cleavage fragments be treated as any other asbestos fiber of the same morphology and chemical composition.²⁷

EPA Region 9 focused on obtaining an accurate count of PCME structures, consistent with our risk assessment protocols and those of Cal/EPA and other health agencies. The counting rules which EPA set for the laboratory were designed to stop counting when a statistically-significant number of PCME fibers were detected. By concentrating on PCME structures, other fiber size classifications may not have been counted to statistical significance. This may have resulted in under counts of other fiber sizes (e.g. the “Berman Crump” protocol fibers referred to in the R. J. Lee Report). **EPA Region 9's study counted PCME structures so that the data could be directly compared to human health epidemiological studies.** These epidemiological studies form the basis for risk assessment models currently used by EPA, Cal/EPA and other federal agencies and international organizations.

R. J. Lee Report Peer Reviews

The R. J. Lee Report was reviewed by three individuals, although research of one of the individuals was extensively quoted in the report and therefore the independence of the reviewer is debatable. The three reviewers generally agree with the conclusions of the R. J. Lee Report regarding aluminum content, fiber chemistry, cleavage fragments, and extinction angles.

Both the R. J. Lee Report and one of the reviewers support use of the original “Berman-

²⁶USEPA (U.S. Environmental Protection Agency) (2003). Report on the Peer Consultation Workshop to Discuss a Proposed Protocol to Assess Asbestos-Related Risk, Final Report. Office of Solid Waste and Emergency Response, Washington D.C. Page 5-5.

²⁷Ibid, page 5-1.

Crump” protocol and calculate a “Berman-Crump” fiber air concentration of 0.0002 fibers/cubic centimeter, using the EPA fibers which they assert meet the “Berman-Crump” definition. The peer reviewer then compares that concentration with an ambient concentration of 0.0008 fibers/milliliter measured in New York City, and states that the “Berman-Crump” value in El Dorado Hills is extremely low. This comparison is flawed for at least two reasons. Significantly, the New York City numbers are based on fibers counted against a totally different size classification (essentially comparing apples to oranges), but **the reviewer also fails to recognize that a concentration of 0.0002 f/cc translates in the protocol to an increased cancer risk of 1 in 1,000 exposed individuals.** This number is disturbingly high and is outside the acceptable cancer risk ranges of EPA, Cal/EPA, and most other state and federal health agencies.

Conclusions

EPA Region 9 has carefully reviewed the R. J. Lee Report and believes that it makes largely unsupported and incorrect conclusions about the EPA Region 9 El Dorado Hills Naturally Occurring Asbestos Exposure Assessment. EPA Region 9 has asked the United States Geological Survey (USGS) to conduct an independent study of the El Dorado County area to address several mineralogical questions raised by the R. J. Lee Report. The USGS study will use sophisticated analytical techniques (such as electron probe micro analysis) to more completely characterize the naturally occurring asbestos in terms of mineral identification and particle morphology.

All of the EPA Region 9 work in El Dorado Hills was, and continues to be, consistent with the EPA’s standard operating and quality control procedures for asbestos work throughout the country.

Exhibit 93



Federal Register

**Friday,
February 29, 2008**

Part IV

Department of Labor

Mine Safety and Health Administration

**30 CFR Parts 56, 57, and 71
Asbestos Exposure Limit; Final Rule**

DEPARTMENT OF LABOR**Mine Safety and Health Administration****30 CFR Parts 56, 57, and 71****RIN 1219-AB24****Asbestos Exposure Limit****AGENCY:** Mine Safety and Health Administration, Labor.**ACTION:** Final rule.

SUMMARY: The Mine Safety and Health Administration (MSHA) is revising its existing health standards for asbestos exposure at metal and nonmetal mines, surface coal mines, and surface areas of underground coal mines. This final rule reduces the permissible exposure limits for airborne asbestos fibers and makes clarifying changes to the existing standards. Exposure to asbestos has been associated with lung cancer, mesothelioma, and other cancers, as well as asbestosis and other nonmalignant respiratory diseases. This final rule will help improve health protection for miners who work in an environment where asbestos is present and lower the risk that miners will suffer material impairment of health or functional capacity over their working lifetime.

DATES: This final rule is effective April 29, 2008.

FOR FURTHER INFORMATION CONTACT:

Patricia W. Silvey at silvey.patricia@dol.gov (E-mail), 202-693-9440 (Voice), or 202-693-9441 (Fax).

SUPPLEMENTARY INFORMATION: The outline of this preamble is as follows:

- I. Summary
- II. Background to the Final Rule
 - A. Scope of Final Rule
 - B. Mineralogy and Analytical Methods for Asbestos
 - C. Summary of Asbestos Health Hazards
 - D. Factors Affecting the Occurrence and Severity of Disease
 - E. MSHA Asbestos Standards
 - F. OSHA Asbestos Standards
- III. Asbestos Exposures in Mines
 - A. Where Asbestos Is Found at Mines
 - B. Sampling Data and Exposure Calculations
 - C. Summary of MSHA's Asbestos Air Sampling and Analysis Results
 - D. Prevention of Asbestos Take-Home Contamination
- IV. Application of OSHA'S Risk Assessment to Mining
 - A. Summary of OSHA's Risk Assessment
 - B. Risk Assessment for the Mining Industry
 - C. Characterization of the Risk to Miners
- V. Section-by-Section Analysis of Final Rule
 - A. Sections 56/57.5001(b)(1) and 71.702(a): Definitions
 - B. Sections 56/57.5001(b)(2) and 71.702(b): Permissible Exposure Limits (PELs)

- C. Sections 56/57.5001(b)(3) and 71.702(c): Measurement of Airborne Fiber Concentration
- D. Section 71.701(c) and (d): Sampling; General Requirements
- VI. Regulatory Analyses
 - A. Executive Order (E.O.) 12866
 - B. Feasibility
 - C. Alternatives Considered
 - D. Regulatory Flexibility Analysis (RFA) and Small Business Regulatory Enforcement Fairness Act (SBREFA)
 - E. Other Regulatory Considerations
- VII. Copy of the OSHA Reference Method (ORM)
- VIII. References Cited in the Preamble

I. Summary

The final rule lowers MSHA's permissible exposure limits (PELs) for asbestos; incorporates the Occupational Safety and Health Administration (OSHA) Reference Method (29 CFR 1910.1001, Appendix A) for MSHA's analysis of mine air samples for asbestos; and makes several clarifying changes to MSHA's existing rule. MSHA is issuing this health standard limiting miners' exposure to asbestos under section 101(a)(6)(A) of the Federal Mine Safety and Health Act of 1977 (Mine Act). MSHA based this final rule on its experience, an assessment of the health risks of asbestos, OSHA's rulemaking history and enforcement experience with its asbestos standard and public comments and testimony on MSHA's asbestos proposed rule.

To protect the health of miners, this final rule lowers MSHA's 8-hour, time-weighted average (TWA), full-shift PEL from 2 fibers per cubic centimeter of air (f/cc) to 0.1 f/cc. The existing excursion limit for metal and nonmetal mines is 10 fibers per milliliter (f/mL) for 15 minutes and the existing excursion limit for coal mines is 10 f/cc for a total of 1 hour in each 8-hour day. This final rule lowers these existing excursion limits to 1 f/cc for 30 minutes. Together, these lower PELs significantly reduce the risk of material impairment for exposed miners. These final PELs are the same as proposed and the same as OSHA's asbestos exposure limits. Although OSHA stated in the preamble to its 1994 final rule (59 FR 40967) that there is a remaining significant risk of material impairment of health or functional capacity at the 0.1 f/cc limit, OSHA concluded that this concentration is "the practical lower limit of feasibility for measuring asbestos levels reliably." MSHA agrees with this conclusion.

To clarify the criteria for the analytical method that MSHA will use to analyze mine air samples for asbestos under this final rule, the rule includes a reference to Appendix A of OSHA's

asbestos standard (29 CFR 1910.1001). Appendix A specifies basic elements of a phase contrast microscopy (PCM) method for analyzing airborne asbestos samples, which includes the same basic analytical elements as those specified in MSHA's existing standards.

Because the risk assessment used as the basis for MSHA's asbestos PELs relies on PCM-based methodology, MSHA will continue to use PCM as the primary methodology for analyzing air samples to determine compliance with the PELs. PCM provides a relatively quick and cost-effective analysis of asbestos samples. In addition, MSHA will continue to follow-up with its policy of using a transmission electron microscopy (TEM) analysis when PCM results indicate a potential overexposure.

MSHA, however, encourages the development of analytical methods specifically for asbestos in mine air samples. MSHA will consider using a method statistically equivalent to Appendix A, if it meets the OSHA Reference Method (ORM) equivalency criteria in OSHA's asbestos standard [29 CFR 1910.1001(d)(6)(iii)] and is recognized by a laboratory accreditation organization. For example, ASTM D7200-06, "Standard Practice for Sampling and Counting Airborne Fibers, Including Asbestos Fibers, in Mines and Quarries, by Phase Contrast Microscopy and Transmission Electron Microscopy," contains the same procedure as NIOSH 7400 to identify fibers. ASTM D7200-06 then has an additional procedure to discriminate potential asbestos fibers, which NIOSH 7400 does not. NIOSH is supporting an ASTM inter-laboratory study to determine whether this additional procedure can be performed accurately and consistently. This procedure was developed in part as a result of this rulemaking and has not been validated.

II. Background to the Final Rule**A. Scope of Final Rule**

This final rule applies to all metal and nonmetal mines, surface coal mines, and surface areas of underground coal mines. It is substantively unchanged from the proposed rule and contains the same PELs and analytical method as in OSHA's asbestos standard. Some commenters supported additional changes to MSHA's definition of asbestos and its analytical method. Others recommended that MSHA propose additional requirements from the OSHA asbestos standard to prevent take-home contamination. Such changes were not contemplated in the proposed

rule and, therefore, are beyond the scope of this final rule.

B. Mineralogy and Analytical Methods for Asbestos

Asbestos is a generic term used to describe the fibrous habits of specific naturally occurring, hydrated silicate minerals. Several federal agencies¹ have regulations that address six asbestos minerals: chrysotile, crocidolite, cummingtonite-grunerite asbestos (amosite), actinolite asbestos, anthophyllite asbestos, and tremolite asbestos. Other agencies address asbestos more generally.²

The terminology used to refer to how minerals form and how they are named is complex. Much of the existing health risk data for asbestos uses the commercial mineral terminology.³ In the asbestiform habit, mineral crystals grow forming long, thread-like fibers. The U.S. Bureau of Mines defined *asbestiform minerals* to be “a certain type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.”⁴ When light pressure is applied to an asbestiform fiber, it bends much like a wire, rather than breaks. In the nonasbestiform habit, mineral crystals do not grow in long thin fibers; they grow in a more massive habit. When pressure is applied, the nonasbestiform crystals fracture into prismatic particles, which are called cleavage fragments because they result from the particle’s breaking or cleavage. Cleavage fragments may be formed when nonfibrous minerals are crushed, as may occur in mining and milling operations. Distinguishing between asbestiform fibers and cleavage fragments in certain size ranges can be difficult or impossible for some minerals.⁵

C. Summary of Asbestos Health Hazards

Studies first identified health problems associated with occupational exposure to asbestos in the early 20th

century among workers involved in the manufacturing or use of asbestos-containing products.⁶ These studies identified the inhalation of asbestos as the cause of asbestosis, a slowly progressive disease that produces lung scarring and loss of lung elasticity. Studies also found that asbestos caused lung and several other types of cancer.⁷ For example, mesotheliomas, rare cancers of the lining of the chest or abdominal cavities, are almost exclusively attributable to asbestos exposure. Once diagnosed, they are rapidly fatal. The damage following many years of workplace exposure to asbestos is generally cumulative and irreversible. Most asbestos-related diseases have long latency periods, typically not producing symptoms for 20 to 30 years following initial exposure. Studies also indicate adverse health effects in workers who have had relatively brief exposures to asbestos.⁸

Several studies have examined respiratory health and respiratory symptoms of asbestos-exposed workers.⁹ Asbestos-induced pleurisy is the most common asbestos-related condition to occur during the 20-year period immediately following a worker’s first exposure to asbestos.¹⁰ Pleural plaques may develop within 10–20 years after an initial asbestos exposure¹¹ and slowly progress in size and amount of calcification, independent of any further exposure. Diffuse pleural thickening and pleural plaques are biologic markers reflecting previous asbestos exposure.¹² In addition, presence in lung tissue of asbestos fibers with a coating of iron and protein, called asbestos bodies, is one of the criteria that serve to support a pathologic diagnosis of asbestosis.¹³ These nonmalignant respiratory conditions can be used to identify at-risk miners prior to their developing a more serious asbestos disease.

Because the hazardous effects from exposure to asbestos are well known, MSHA’s discussion in this section will focus on the results of studies and literature reviews published since the publication of OSHA’s risk assessment,

and those involving miners. One such review by Tweedale (2002) stated,

Asbestos has become the leading cause of occupational related cancer death, and the second most fatal manufactured carcinogen (after tobacco). In the public’s mind, asbestos has been a hazard since the 1960s and 1970s. However, the knowledge that the material was a mortal health hazard dates back at least a century, and its carcinogenic properties have been appreciated for more than 50 years.

Greenberg (2003) also published a recent review of the biological effects of asbestos and provided a historical perspective similar to that of Tweedale.

The three most commonly described adverse health effects associated with asbestos exposure are lung cancer, mesotheliomas, and pulmonary fibrosis (i.e., asbestosis). OSHA, in its 1986 asbestos rule, reviewed each of these diseases and provided details on the studies demonstrating the relationship between asbestos exposure and the clinical evidence of disease.¹⁴ In 2001, the Agency for Toxic Substances and Disease Registry (ATSDR) published an updated *Toxicological Profile for Asbestos* that also included an extensive discussion of these three diseases. A search of peer-reviewed scientific literature yielded many new articles¹⁵ that continue to demonstrate and support findings of asbestos-induced lung cancer, mesotheliomas, and asbestosis, consistent with the conclusions of OSHA and ATSDR. Thus, in the scientific community, there is compelling evidence of the adverse health effects of asbestos exposure.

D. Factors Affecting the Occurrence and Severity of Disease

The toxicity of asbestos, and the subsequent occurrence of disease, is related to its concentration in the air and the duration of exposure. Other variables, such as the fiber’s characteristics or the effectiveness of a person’s lung clearance mechanisms, lung fiber burden, residence-time-weighted cumulative exposures, and susceptible populations are also relevant factors affecting disease severity.¹⁶

1. Fiber Concentration

Early airborne asbestos dust measurements had counted particles

¹ In addition to MSHA’s and OSHA’s existing worker protection standards, other federal statutory and regulatory requirements that apply only to the six commercial varieties of asbestos include the Asbestos Hazard Emergency Response Act (AHERA) [15 U.S.C. 2642(3)] and the Clean Air Act’s National Emission Standards for Hazardous Air Pollutants (NESHAP) [40 CFR 61.141].

² Asbestos is listed as a hazardous air pollutant under the Clean Air Act [42 U.S.C. 7412(b)(1)]; as a hazardous substance under the Comprehensive Environmental Response, Compensation and Liability Act [40 CFR 302.4]; and in EPA’s Integrated Risk Information System (IRIS), a collection of health assessment information regarding the toxicity of asbestos, <http://www.epa.gov/IRIS/subst/0371.htm>.

³ Asbestos mineralogy was discussed more fully in the proposed rule (70 FR 43952–43953).

⁴ U.S. Bureau of Mines (Campbell *et al.*), 1977.

⁵ Meeker *et al.*, 2003.

⁶ GETF Report, p. 38, 2003; OSHA (40 FR 47654), 1975.

⁷ Doll, 1955; Reeves *et al.*, 1974; Becker *et al.*, 2001; Browne and Gee, 2000; Sali and Boffetta, 2000; IARC, 1987.

⁸ Sullivan, 2007.

⁹ Wang *et al.*, 2001; Delpierre *et al.*, 2002; Eagen *et al.*, 2002; Selden *et al.*, 2001.

¹⁰ Rudd, 2002.

¹¹ Bolton *et al.*, 2002; OSHA, 1986.

¹² ATSDR, 2001; Manning *et al.*, 2002.

¹³ ATSDR, 2001; Peacock *et al.*, 2000; Craighead *et al.*, 1982.

¹⁴ Berry and Newhouse, 1983; Dement *et al.*, 1982; Finkelstein, 1983; Henderson and Enterline, 1979; Peto, 1980; Peto *et al.*, 1982; Seidman *et al.*, 1979; Seidman, 1984; Selikoff *et al.*, 1979; Weill *et al.*, 1979.

¹⁵ Baron, 2001; Bolton *et al.*, 2002; Manning *et al.*, 2002; Nicholson, 2001; Osinubi *et al.*, 2000; Roach *et al.*, 2002.

¹⁶ ICRP, 1966; EPA, 1986; West, 2000 and 2003; Manning *et al.*, 2002.

and reported the results as millions of particles per cubic foot of air (mppcf). Most recent studies express the concentration of asbestos as the number of fibers per cubic centimeter (f/cc). Some studies have also reported asbestos concentrations in the number of fibers per milliliter (f/mL), which is an equivalent concentration to f/cc. MSHA's existing PELs for asbestos are expressed in f/mL for metal and nonmetal mines and as f/cc for coal mines. To improve consistency and avoid confusion, MSHA expresses the concentration of asbestos fibers as f/cc in this final rule, for both coal and metal and nonmetal mines.

In the late 1960s, scientists correlated PCM-based fiber counting methods with the earlier types of dust measurements, which provided a means to estimate earlier workers' asbestos exposures and enabled researchers to develop a dose-response relationship with the occurrence of disease. The British Occupational Hygiene Society reported¹⁷ that a worker exposed to 100 fiber-years per cubic centimeter (e.g., 50 years at 2 f/cc, 25 years at 4 f/cc, 10 years at 10 f/cc) would have a 1 percent risk of developing early signs of asbestosis. The correlation of exposure levels with the disease experience of populations of exposed workers provided a basis for setting an occupational exposure limit for asbestos measured by the concentration of the fibers in air.

OSHA (51 FR 22617) applied a conversion factor of 1.4 to convert mppcf, which includes all particles of respirable size, to f/cc, which includes only those particles greater than 5 μ m in length with at least a 3:1 aspect ratio. More recently, Hodgson and Darnton (2000) recommended the use of a factor of 3. In reviewing the scientific literature, MSHA did not critically evaluate the impact of these and other conversion factors. MSHA notes this difference here for completeness. MSHA is relying on OSHA's risk assessment and, thus, is using OSHA's conversion factor.

2. Duration of Exposure

The duration of exposure (T) is reported in both epidemiological and toxicological studies, and is generally much shorter in animal studies (e.g., months versus years). In epidemiological studies involving toxic substances that do not have acute health effects, such as asbestos, duration of exposure is typically expressed in years.

3. Cumulative Exposure

When developing dose-response relationships for asbestos-induced health effects, researchers typically use the product of exposure concentration (C in f/cc) and exposure duration (T in years), expressed as fiber-years,¹⁸ to indicate the level of exposure or dose. When summed over all periods of exposure, this measure is called cumulative exposure. Because of the difficulties in obtaining good quantitative exposure assessments, cumulative exposure expressed in fiber-years is often selected as the common metric for the levels of exposures reported in epidemiological studies.

Finkelstein¹⁹ noted that this product of exposure concentration times duration of exposure (C \times T) assumes an equal weighting of each variable (C, T). Finkelstein stated further that exposure at a low concentration for a long period of time may be numerically equivalent to exposure at a high concentration for short periods of time; but, they may not be biologically equivalent. What this means is that, in some studies, either concentration or duration of exposure may be more important in predicting disease. For example, in the case of mesothelioma risk following asbestos exposure, Finkelstein²⁰ concluded that “* * * duration of exposure may dominate the exposure term * * *”.

4. Fiber Characteristics

Baron (2001) reviewed techniques for the measurement of fibers and stated, “* * * fiber dose, fiber dimension, and fiber durability are the three primary factors in determining fiber toxicity * * *”. Manning *et al.* (2002) also noted the important roles of bio-persistence (i.e., durability), physical properties, and chemical properties in defining the “toxicity, pathogenicity, and carcinogenicity” of asbestos. Roach *et al.* (2002) stated that—

Physical properties, such as length, diameter, length-to-width (aspect ratio), and texture, and chemical properties are believed to be determinants of fiber distribution [in the body] and disease severity.

Many other investigators²¹ also have concluded that the dimensions of asbestos fibers are biologically important.

The NIOSH 7400 analytical method used by MSHA's contract laboratories specifies that analysts count those fibers that are greater than 5 micrometers

(microns, μ m) in length with a length to diameter aspect ratio of at least 3:1. Several recent publications²² support this aspect ratio, although larger aspect ratios such as 5:1 or 20:1 have been proposed.²³ There is some evidence that longer, thinner asbestos fibers (e.g., greater than 20 μ m long and less than 1 μ m in diameter) are more potent carcinogens than shorter fibers. Suzuki and Yuen (2002), however, concluded that “Short, thin asbestos fibers should be included in the list of fiber types contributing to the induction of human malignant mesotheliomas * * *”. More recently, Dodson *et al.* (2003) concluded that all lengths of asbestos fibers induce pathological responses and that researchers should exercise caution when excluding a population of inhaled asbestos fibers based on their length.

Researchers have found neither a reliable method for predicting the contribution of fiber length to the development of disease, nor evidence establishing the exact relationship between them. There is suggestive evidence that the dimensions of asbestos fibers may vary with different diseases. A continuum may exist in which shorter, wider fibers produce one disease, such as asbestosis, and longer, thinner fibers produce another, such as mesotheliomas.²⁴

Some commenters suggested that MSHA consider additional fiber characteristics, such as durability, in evaluating risk. Some emphasized that not all fibers with the same dimensions will lead to the same disease endpoint. The science is inconclusive on the relationship between the various fiber characteristics and the disease endpoints.²⁵

E. MSHA Asbestos Standards

The early PELs for asbestos in mining dropped dramatically as more information on the health effects of asbestos exposure became evident 20 to 30 years (latency period) following its widespread use during the 1940s.

Year	8-hour TWA, Asbestos PEL
1967	5 mppcf (30 f/mL)
1969	2 mppcf (12 f/mL)
1974	5 f/mL for metal and nonmetal mines
1976	2 f/cc for surface areas of coal mines (41 FR 10223)
1978	2 f/mL for metal and nonmetal mines (43 FR 54064)

²² ATSDR, 2001; Osinubi *et al.*, 2000.

²³ Wylie *et al.*, 1985.

²⁴ ATSDR, pp. 39–41, 2001; ATSDR, 2003; Mossman, pp. 47–50, 2003; Kuempel *et al.*, 2006.

²⁵ Hodgson and Darnton, 2000; Browne, 2001; Liddell, 2001; ATSDR, 2001.

¹⁷ Lane *et al.*, 1968; OSHA (40 FR 47654), 1975; NIOSH, 1980.

¹⁸ ATSDR, 2001; Fischer *et al.*, 2002; Liddell, 2001; Pohlabeln *et al.*, 2002.

¹⁹ Finkelstein, 1995; ATSDR, p. 42, 2001.

²⁰ Finkelstein, 1995

²¹ ATSDR, 2001; ATSDR, 2003; Osinubi *et al.*, 2000; Peacock *et al.*, 2000; Langer *et al.*, 1979.

On March 29, 2002 (67 FR 15134), MSHA published an advance notice of proposed rulemaking to obtain public comment on how best to protect miners from exposure to asbestos. MSHA published the proposed rule on July 29, 2005 (70 FR 43950) and held two public hearings in October 2005.

F. OSHA's Asbestos Standards

Like MSHA's, OSHA's 8-hour TWA PEL for occupational exposure to asbestos dropped dramatically over the past several decades.

Year	8-hour TWA Asbestos PEL
1971	12 f/cc
1971	5 f/cc
1972	2 f/cc
1983	0.5 f/cc ²⁶
1986	0.2 f/cc ²⁷
1994	0.1 f/cc

In addition, on September 14, 1988, OSHA promulgated an asbestos excursion limit of 1 f/cc over a sampling period of 30 minutes (53 FR 35610).

OSHA's 1986 standards had applied to occupational exposure to both asbestiform and nonasbestiform actinolite, tremolite, and anthophyllite. On June 8, 1992, OSHA removed the nonasbestiform types of these minerals from the scope of its asbestos standards (57 FR 24310).

III. Asbestos Exposures in Mines

A. Where Asbestos Is Found at Mines

Asbestos exposure of miners can come from either naturally occurring asbestos in the ore or host rock or from asbestos contained in manufactured products.

1. Metal and Nonmetal Mines

The National Institute for Occupational Safety and Health (NIOSH) and other research organizations and scientists have noted the occurrence of cancers and asbestosis among miners involved in the mining and milling of commodities that contain asbestos.²⁸ (See Table IV-3.) Although asbestos is no longer mined as a commodity in the United States, veins, pockets, or intrusions of asbestos-containing minerals have been found in other ores in specific geographic regions, primarily in metamorphic or igneous rock.²⁹ It is possible to find

asbestos in sedimentary rock. The U.S. Geological Survey (USGS) has reported weathering or abrasion of asbestos-bearing rock and soil, or air transportation, to carry asbestos to sedimentary deposits.³⁰ MSHA's experience is that miners may encounter asbestos during the mining of a number of mineral commodities,³¹ such as talc, limestone and dolomite, vermiculite, wollastonite, banded ironstone and taconite, lizardite, and antigorite. Even if asbestos contamination is found in a specific mineral commodity, not all mines of that commodity will encounter asbestos and those that do may encounter it rarely. (See Table III-1.)

Mining activities, such as blasting, cutting, crushing, grinding, or simply disturbing the ore or surrounding earth may cause asbestos fibers to become airborne.³² Milling may transform bulk ore containing asbestos into respirable fibers. Asbestos tends to deposit on workplace surfaces and accumulate during the milling process, which is often in enclosed buildings. The use of equipment and machinery or other activities in these locations may re-suspend the asbestos-containing dust from these surfaces into the air. For this reason, MSHA generally finds higher asbestos concentrations in mills than among mobile equipment operators or in ambient environments, such as pits.

Some mine operators are making an effort to avoid deposits that are likely to contain asbestos minerals. They use knowledge of the geology of the area, core or bulk sample analysis, and workplace examinations (of the pit) to avoid encountering asbestos deposits, thus preventing asbestos contamination of their process stream and final product.³³

2. Coal Mines

MSHA is aware of only one coal formation in the United States that contains naturally occurring asbestos; however, there is no coal mining in this formation.³⁴ The more likely exposure to asbestos in coal mining occurs at surface operations from introduced asbestos-containing materials (ACM).

3. Asbestos-Containing Materials (ACM)

Asbestos is a component in some commercial products and may be found

as a contaminant in others. The USGS estimates that, during 2006, manufacturers in the United States used about 2,340 metric tons (5.2 million pounds) of asbestos, primarily in roofing products and coatings and compounds. In addition to domestic manufacturing, the United States continues to import products that contain asbestos, primarily cement products, such as flat cement panels, sheets, and tiles.³⁵

Although manufacturers have removed the asbestos from many new products,³⁶ asbestos may still be found at mines. Asbestos-containing building materials (ACBM), such as Transite® board and reinforced cements, could present a hazard during maintenance, construction, remodeling, rehabilitation, or demolition projects. Asbestos in manufactured products, such as electrical insulation, joint and packing compounds, automotive clutch and brake linings,³⁷ and fireproof protective clothing and welding blankets, could present a hazard during activities at the mine site that may cause a release of fibers.³⁸ MSHA expects mine operators to determine whether ACM or ACBM are present on mine property by reading the labels or Material Safety Data Sheets (MSDS) required by the OSHA Hazard Communication Standard (29 CFR 1910.1200). The presence of asbestos at a mine indicates that there is a potential for exposure.

B. Sampling Data and Exposure Calculations

To evaluate asbestos exposures in mines, MSHA collects personal exposure samples. MSHA samples a miner's entire work shift using a personal air-sampling pump and a filter-cassette assembly. This assembly is composed of a 50-mm static-reducing, electrically conductive, extension cowl and a 0.8 µm pore size, 25-mm diameter, mixed cellulose ester (MCE) filter. Following standard sampling procedures, MSHA also submits blank filters for analysis.

MSHA collects a sample over the entire time the miner works; 10- to 12-hour shifts are common. The time-weighted average (TWA) PELs in MSHA's standards, however, are based on an 8-hour workday. Regardless of the actual shift length, MSHA calculates a full-shift concentration as if the fibers had been collected over an 8-hour shift. For work schedules less than or greater than 8 hours, this technique allows MSHA to compare a miner's exposure

²⁶ U.S. Court of Appeals for the 5th Circuit invalidated this rule on March 7, 1984, in *Asbestos Information Association/North America v. OSHA* (727 F.2d 415, 1984).

²⁷ OSHA added specific provisions in the construction standard to cover unique hazards relating to asbestos abatement and demolition jobs.

²⁸ NIOSH WoRLD, 2003.

²⁹ MSHA (Bank), 1980; Ross, 1978.

³⁰ USGS, 1995.

³¹ Roggli *et al.*, 2002; Selden *et al.*, 2001; Amandus *et al.*, Part I, 1987; Amandus *et al.*, Part III, 1987; Amandus and Wheeler, Part II, 1987; Meeker *et al.*, 2003.

³² MSHA (Bank), 1980; Amandus *et al.*, Part I, 1987.

³³ GETF Report, pp. 17-18, 2003; Nolan *et al.*, 1999.

³⁴ Brownfield *et al.*, 1995.

³⁵ USGS (Virta), 2007.

³⁶ GETF Report, pp. 12 and 15, 2003.

³⁷ Lemen, 2003; Paustenbach *et al.*, 2003.

³⁸ EPA, 1986; EPA, 1993; EPA, October 2003.

directly to the 8-hour TWA PEL. MSHA calls this calculated equivalent, 8-hour TWA a "shift-weighted average" (SWA).

MSHA's existing sampling procedures specify using several, typically three, filter-cassette assemblies in a consecutive series to collect a full-shift sample. For results from both PCM and TEM analyses, MSHA calculates the SWA exposure levels for each miner sampled from the individual filters according to the following formulas.

$$SWA = (TWA_{1t_1} + TWA_{2t_2} + \dots + TWA_{nt_n}) / 480 \text{ minutes}$$

Where:

TWA_n is the time-weighted average concentration for filter "n" calculated by dividing the number of fibers (f) collected on the filter by the volume of air (cc) drawn through the filter.

t_n is the duration sampled in minutes for filter "n".

Some commenters criticized MSHA's sampling and analytical procedures. A few commenters believed that MSHA should develop specific test procedures for the sampling and analysis of bulk samples for the mining environment, as well as specific air sampling procedures. Some commenters suggested that respirable dust sampling using a cyclone might be a means to remove interfering dust from the sample. NIOSH recommended that thoracic samplers be evaluated in a mining environment. Cyclones and thoracic samplers are not included in MSHA's existing sampling and analytical protocols for asbestos and are

not included in existing approved methods. Exposures determined using these devices have not been correlated with the risk assessment that forms the basis of the PELs in the final rule.

Some commenters supported MSHA's existing asbestos monitoring protocols with emphasis on full-shift monitoring for comparison to the PEL. Other commenters stated that MSHA's existing field sampling and analysis methods are adequate for most mines and quarries, particularly when no significant amount of asbestos is found.

Some commenters stated that MSHA should improve its inspection reports by including inspection field notes; sampling location, purpose, and procedure; as well as descriptions of the accuracy, meaning, and limitations of the analytical results. MSHA routinely provides the sampling and analytical results and, when requested, will provide the additional information.

C. Summary of MSHA's Asbestos Air Sampling and Analysis Results

To assess personal exposures and present the Agency's sampling data for January 1, 2000 through May 31, 2007, MSHA calculated an SWA exposure for each miner from the TWA results of individual filters. MSHA has compiled these data into a PowerPoint® slide, and has posted it, together with additional explanatory information, on MSHA's Asbestos Single Source Page at <http://www.msha.gov/asbestos/asbestos.htm>.

MSHA conducted asbestos sampling at 207 mines (206 non-asbestos metal and nonmetal mines and one coal mine) during the period January 1, 2000 through May 31, 2007. Some were sampled multiple times over the seven and one quarter years. MSHA found 29 mines with at least one miner exposed to an equivalent 8-hour TWA (SWA) fiber concentration exceeding 0.1 f/cc. Out of a total of 917 SWA personal full-shift fiber exposure sample results, 113 (12 percent) exceeded 0.1 f/cc using the existing PCM-based analytical screening method.

Further analysis of the 113 samples with TEM confirmed asbestos fiber exposures exceeding 0.1 f/cc in 23 of them. Using the existing TEM-based analytical method, 3 percent of the total number of SWA samples taken exceeded 0.1 asbestos f/cc. Five mines (two taconite, one wollastonite, one sand and gravel, and one olivine), out of the 29 mines potentially impacted by lowering the PEL, had at least one miner with an SWA asbestos fiber exposure exceeding 0.1 f/cc. Although MSHA has no evidence of asbestos exposure above the new PEL in coal mines, the Agency anticipates that some coal mines will encounter asbestos from asbestos containing materials (ACM) brought onto mine property. These operators may have to take corrective action. Table III-1 below summarizes MSHA's asbestos sampling results for the period January 2000 through May 2007.

TABLE III-1.—PERSONAL EXPOSURE SAMPLES AT MINES¹ BY COMMODITY

[1/2000–5/2007]

Commodity	Number of mines sampled	Number (%) of mines with SWA samples >0.1 f/cc by PCM	Number of SWA samples	Number (%) of SWA samples >0.1 f/cc by PCM ²	Number (%) of SWA samples >0.1 f/cc by TEM
Rock & quarry products ³	127	11 (9%)	326	20 (6%)	2 (1%)
Vermiculite	4	3 (75%)	149	13 (9%)	0
Wollastonite	1	1 (100%)	18	18 (100%)	9 (50%)
Iron (taconite)	15	5 (33%)	254	43 (17%)	11 (4%)
Talc	12	1 (8%)	38	2 (5%)	0
Alumina ⁴	1	0	1	0	0
Feldspar	7	0	56	0	0
Boron	2	1 (50%)	12	7 (58%)	0
Olivine	2	2 (100%)	9	3 (33%)	1 (11%)
Other ⁶	36	7 (14%)	104	7 (6%)	0
TOTAL	207	29 (14%)	917	113 (12%)	23 (3%)

¹ Excludes data from an asbestos mine and mill closed in 2003.

² MSHA uses TEM to identify asbestos on samples with results exceeding 0.1 f/cc.

³ Including stone, and sand and gravel mines.

⁴ 15-minute sample.

⁵ Incomplete SWA at one mine.

⁶ Coal, potash, gypsum, cement, perlite, clay, lime, mica, metal ore NOS, shale, pumice, trona, salt, gold, and copper.

⁷ Coal, potash, gypsum, cement, and perlite. (Coal and potash exposures were due to fiber release episodes from commercially introduced asbestos).

⁸ TEM confirmed airborne asbestos exposures exceeding 0.1 f/cc at five (2%) mines.

The USGS has published a series of maps showing historic asbestos prospects and natural asbestos occurrences in the United States. The USGS published a map covering the eastern states in 2005; the central states in 2006; and the Rocky Mountain states in 2007. These maps served as a guide for the investigation of possible naturally occurring asbestos within the vicinity of mining operations. MSHA found that stone mines and quarries are the predominate types of mining operations in the vicinity of naturally occurring asbestos locations identified on the maps. MSHA conducted fiber sampling at these mines to screen for potential asbestos exposures. The results of the sampling indicated a small degree of asbestos at some of these mining operations, but no widespread asbestos contamination. Although not included on the USGS maps, MSHA also surveyed two mines in El Dorado County, California. Sampling at one of the mines resulted in two personal asbestos exposures greater than 0.1 f/cc, confirmed by TEM analysis, and 2 to 5 percent naturally occurring asbestos in an associated bulk sample. Air sampling at the other mine had low PCM fiber results.

D. Asbestos Take-Home Contamination

The final rule, like the proposal, does not address take-home contamination. In making this decision, MSHA considered its enforcement experience; comments and testimony on the proposal; as well as OSHA, NIOSH, and EPA publications and experience.³⁹ MSHA based its determination to address asbestos take-home

contamination, without promulgating new regulatory provisions, on the following factors:

- There are no asbestos mines or mills currently operating in this country and different ore bodies of the same commodity, such as vermiculite mining, are not consistent in the presence, amount, or dispersion of asbestiform minerals. Based on MSHA's recent enforcement sampling, asbestos exposures in mining are low. (See Table III-1.)

- The measures taken to prevent take-home contamination are varied. Operators may choose the most effective method for eliminating this hazard based on the unique conditions in the mine, including the nature of the hazard. For example, in one situation providing disposable coveralls could minimize or prevent asbestos take-home contamination. Another situation may require on-site shower facilities coupled with clothing changes to provide the same protection.

- Existing standards (e.g., personal protection §§ 56/57.15006; sanitation §§ 56/57.20008, 56/57.20014, 71.400, 71.402; housekeeping §§ 56/57.16003, 56/57.20003, 77.208; appropriate actions §§ 56/57.18002, 56/57.20011, 77.1713; hazard communication 30 CFR 46, 47, and 48), together with lower PELs, provide sufficient enforcement authority to ensure that mine operators take adequate measures when necessary to prevent asbestos take-home contamination.

Commenters urged MSHA to expand the rulemaking to include specific requirements to prevent take-home contamination. NIOSH also encouraged MSHA to adopt measures included in

its 1995 Report to Congress on their *Workers' Home Contamination Study Conducted under the Workers' Family Protection Act*. Other commenters, however, supported MSHA's decision and stated that take-home contamination requirements could not be justified at this time.

IV. Application of OSHA's Risk Assessment to Mining

MSHA has determined that OSHA's 1986 asbestos risk assessment (51 FR 22644) is applicable to asbestos exposures in mining. In developing this final rule, MSHA also evaluated studies published since OSHA completed its 1986 risk assessment, and studies that specifically focused on asbestos exposures of miners. These additional studies corroborate OSHA's conclusions in its risk assessment.

A. Summary of OSHA's Risk Assessment

1. Cancer Mortality

In its 1986 risk assessment, OSHA estimated cancer mortality for workers exposed to asbestos at various cumulative exposures (i.e., combining exposure concentration and duration of exposure). MSHA has reproduced this data in Table IV-1. Table IV-1 shows that the estimated mortality from asbestos-related cancer decreases significantly by lowering exposure. This is true regardless of the type of cancer, e.g., lung, pleural or peritoneal mesotheliomas, or gastrointestinal. Although excess relative risk is linear in dose, the excess mortality rates in Table IV-1 are not.⁴⁰

TABLE IV-1.—ESTIMATED ASBESTOS-RELATED CANCER MORTALITY PER 100,000 BY NUMBER OF YEARS EXPOSED AND EXPOSURE LEVEL

Asbestos fiber concentration (f/cc)	Cancer mortality per 100,000 exposed			
	Lung	Mesothelioma	Gastro-intestinal	Total
1-year exposure				
0.1	7.2	6.9	0.7	14.8
0.2	14.4	13.8	1.4	29.6
0.5	36.1	34.6	3.6	74.3
2.0	144	138	14.4	296.4
4.0	288	275	28.8	591.8
5.0	360	344	36.0	740.0
10.0	715	684	71.5	1,470.5
20-year exposure				
0.1	139	73	13.9	225.9
0.2	278	146	27.8	451.8
0.5	692	362	69.2	1,123.2
2.0	2,713	1,408	271.3	4,392.3
4.0	5,278	2,706	527.8	8,511.8

³⁹ NIOSH (Report to Congress) September 1995.

⁴⁰ Nicholson, p. 53, 1983.

TABLE IV-1.—ESTIMATED ASBESTOS-RELATED CANCER MORTALITY PER 100,000 BY NUMBER OF YEARS EXPOSED AND EXPOSURE LEVEL—Continued

Asbestos fiber concentration (f/cc)	Cancer mortality per 100,000 exposed			
	Lung	Mesothelioma	Gastro-intestinal	Total
5.0	6,509	3,317	650.9	10,476.9
10.0	12,177	6,024	1,217.7	13,996.7
45-year exposure				
0.1	231	82	23.1	336.1
0.2	460	164	46.0	670.0
0.5	1,143	407	114.3	1,664.3
2.0	4,416	1,554	441.6	6,411.6
4.0	8,441	2,924	844.1	12,209.1
5.0	10,318	3,547	1,031.8	14,896.8
10.0	18,515	6,141	1,851.5	26,507.5

Table IV-1 shows that, by lowering the PEL from 2 f/cc to 0.1 f/cc, the risk of cancer mortality drops 95 percent from an estimated 6,411 to 336 deaths (per 100,000 workers).

2. Asbestosis

Finkelstein (1982) studied a group of 201 men who worked in a factory in Ontario, Canada, that manufactured asbestos-cement pipe and rock-wool insulation. Finkelstein demonstrated that there was a relationship between cumulative asbestos exposure and confirmed asbestosis.

Berry and Lewinsohn (1979) studied a group of 379 men who worked in an asbestos textile factory in northern England. Berry and Lewinsohn (1979) defined two different cohorts: Men who were first employed before 1951, when asbestos fiber levels were estimated; and men first employed after 1950, when asbestos fiber levels were measured. They plotted cases of possible asbestosis to determine a dose response curve.

OSHA stated that “* * * the best estimates of asbestosis incidence are derived from the Finkelstein data * * *” (48 FR 51132). OSHA did not rely on the values for the slope as

determined by Berry and Lewinsohn (1979). Based on Finkelstein’s (1982) linear relationship for lifetime asbestosis incidence, OSHA calculated estimates of lifetime asbestosis incidence at five exposure levels of asbestos (i.e., 0.5, 1, 2, 5, and 10 f/cc) and published its estimate in tabular form (48 FR 51132). MSHA has reproduced OSHA’s estimates in Table IV-2 below. OSHA stated (51 FR 22646) that “Reducing the exposure to 0.2 f/cc, a concentration not included in Table IV-2, would result in a lifetime incidence of asbestosis of 0.5%.”

TABLE IV-2.—ESTIMATES OF LIFETIME ASBESTOSIS INCIDENCE ⁴¹

Exposure level, f/cc	Percent (%) Incidence		
	Finkelstein	Berry and Lewinsohn (employed before 1951)	Berry and Lewinsohn (first employed after 1950)
0.5	1.24	0.45	0.35
1	2.49	0.89	0.69
2	4.97	1.79	1.38
5	12.43	4.46	* 3.45
10	24.86	8.93	6.93
Slope	0.055	0.020	0.015
R ²	0.975	0.901	0.994

* Note: 1.38 in original table was a typographical error. The text (48 FR 51132) and the regression formula indicate that 3.45 is the correct percent.

Similar to the cancer risk, Table IV-2 shows a significant reduction in the incidence of asbestosis by lowering asbestos exposures. MSHA calculated the incidence of asbestosis following 45 years of exposure to asbestos at a concentration of 0.1 f/cc, which OSHA had not included in Table IV-1, to be 0.25 percent or 250 cases per 100,000 workers. Thus, by lowering the 8-hour

TWA PEL from 2 f/cc to 0.1 f/cc, MSHA will reduce the lifetime asbestosis risk by 95 percent from an estimated 4,970 cases to 250 cases (per 100,000 workers).

B. Risk Assessment for the Mining Industry

OSHA stated in the preamble to its 1986 asbestos rule that it excluded

mining studies in its risk assessment because it believed that risks in the asbestos mining-milling operations are lower than other industrial operations due to differences in fiber size (51 FR 22637). MSHA reviewed the studies OSHA used to develop its risk assessment.⁴² In addition, MSHA obtained and reviewed the latest available scientific studies on the health

⁴¹ Finkelstein, 1982; Berry and Lewinsohn, 1979.

⁴² Berry and Newhouse, 1983; Dement *et al.*, 1982; Finkelstein, 1983; Henderson and Enterline, 1979; Peto, 1980; Peto *et al.*, 1982; Seidman *et al.*,

1979; Seidman, 1984; Selikoff *et al.*, 1979; Weill *et al.*, 1979.

effects of asbestos exposure. MSHA recognizes that there are uncertainties in any risk assessment. MSHA concluded, however, that these studies provide further support of the significant risk of adverse health effects following exposure to asbestos.

MSHA reviewed the mining studies described in OSHA's asbestos risk assessment, as well as other studies that involved the exposure of miners to asbestos. Most of these studies were conducted in Canada, although some have been conducted in Australia, India,

Italy, South Africa, and the United States. Table IV-3 lists some of these mining studies, in chronological order, and gives the salient features of each study. These studies are in MSHA's rulemaking docket.

TABLE IV.-3—SELECTED STUDIES INVOLVING MINERS EXPOSED TO ASBESTOS

Author(s), year of publication	Study group, type of asbestos	Major finding(s) or conclusion(s)
Rossiter <i>et al.</i> , 1972	Canadian miners and millers, Chrysotile	Radiographic changes (opacities) related to age and exposure.
Becklake, 1979	Canadian miners and millers, Chrysotile	Weak relationship between exposure and disease.
Gibbs and du Toit, 1979	Canadian and South African miners, Chrysotile.	Need for workplace epidemiologic surveillance and environmental programs.
Irwig <i>et al.</i> , 1979	South African miners, Amosite and Crocidolite	Parenchymal radiographic abnormalities preventable by reduced exposure.
McDonald and Liddell, 1979	Canadian miners and millers, Chrysotile	Lower risk of mesotheliomas and lung cancer from chrysotile than crocidolite.
Nicholson <i>et al.</i> , 1979	Canadian miners and millers, Chrysotile	Miners and millers: at lower risk of mesotheliomas, at risk of asbestosis (as factory workers and insulators), at risk of lung cancer (as factory workers).
Rubino <i>et al.</i> , Ann NY Ac Sci 1979.	Italian miners, Chrysotile	Role of individual susceptibility in appearance and progression of asbestosis.
Rubino <i>et al.</i> , Br J Ind Med 1979.	Italian miners, Chrysotile	Elevated risk of lung cancer.
Solomon <i>et al.</i> , 1979	South African miners, Amosite and Crocidolite	Sign of exposure to asbestos: thickened interlobar fissures.
McDonald <i>et al.</i> , 1980	Canadian miners and millers, Chrysotile	No statistically significant increases in SMRs.
McDonald <i>et al.</i> , 1986	U.S. miners, Tremolite.	A. Increased risk of mortality from respiratory cancer.
McDonald <i>et al.</i> , 1986	U.S. miners, Tremolite	B. Increased prevalence of small opacities by retirement age.
Cookson <i>et al.</i> , 1986	Australian miners and millers, Crocidolite	No threshold dose for development of radiographic abnormality.
Amandus <i>et al.</i> , 1987	U.S. miners and millers, Tremolite-Actinolite ...	Part I: Exposures below 1 f/cc after 1977, up to 100–200 × higher in 1960's and 1970's.
Amandus and Wheeler, 1987 ...	U.S. miners and millers, Tremolite-Actinolite ...	Part II: Increased mortality from nonmalignant respiratory disease and lung cancer.
Amandus <i>et al.</i> , 1987	U.S. miners and millers, Tremolite-Actinolite ...	Part III: Increased prevalence of radiographic abnormalities associated with past exposure.
Armstrong <i>et al.</i> , 1988	Australian miners and millers, Crocidolite	Increased mortality from mesotheliomas and lung cancer.
Enarson <i>et al.</i> , 1988	Canadian miners, Chrysotile	Increased cough, breathlessness, abnormal lung volume and capacity.
McDonald <i>et al.</i> , 1988	U.S. miners and millers, Tremolite	Low exposure and no statistically significant SMRs.
McDonald <i>et al.</i> , 1993	Canadian miners and millers, Chrysotile	Increased SMRs for lung cancer and mesotheliomas as cohort aged.
Dave <i>et al.</i> , 1996	Indian miners and millers, Chrysotile	Higher exposures in surface than underground mines; higher exposures in mills than mines; restrictive lung impairment and radiologic parenchymal changes more common in millers.
McDonald <i>et al.</i> , 1997	Canadian miners and millers, Chrysotile	Risk of mesotheliomas related to geography and mineralogy of region; mesotheliomas caused by amphiboles.
Nayebzadeh <i>et al.</i> , 2001	Canadian miners and millers, Chrysotile	Respiratory disease related to regional differences in fiber concentration and not dimension.
Ramanathan and Subramanian, 2001.	Indian miners and millers, Chrysotile and tremolite.	Increased risk of cancer, restrictive lung disease, radiologic changes, and breathing difficulties; more common in milling.
Bagatin <i>et al.</i> , 2005	Brazilian miners and millers, Chrysotile	Decreased risk of non-malignant abnormalities with improvements in workplace conditions.
Nayebzadeh <i>et al.</i> , 2006	Canadian miners and millers, Chrysotile, Tremolite, Amosite.	Possible use of lung fiber concentration, especially short tremolite fibers, to predict fibrosis grade.
Sullivan, 2007	U.S. miners, millers, and processors, Tremolite.	Increased mortality from asbestosis, cancer of the pleura, and lung cancer that were dose-related.

MSHA found that many of the observations presented in these mining studies (e.g., age of first exposure, latency, radiologic changes) are consistent with those from the studies OSHA relied on in its risk assessment, as well as studies of other asbestos-exposed factory and insulation workers.

MSHA concludes that exposure to asbestos, a known human carcinogen, results in similar disease endpoints regardless of the occupation that has been studied. Because there is evidence of asbestos-related disease among miners, MSHA is applying the OSHA risk assessment to the mining industry.

Some commenters stated that there is a differential health risk related to fiber type and that OSHA's risk assessment is not adequate or appropriate for the mining industry. The OSHA risk assessment addresses adverse health effects from exposure to six asbestos minerals. MSHA applies TEM analysis

to its PCM results to determine exposure to these same six asbestos minerals. Exposure of miners to these asbestos minerals, at the same concentrations and length of exposures as workers in other industries, can be expected to result in the same disease endpoints as quantified in OSHA's risk assessment. (See section II.C and II.D of this preamble and chapter III of the REA.)

Some commenters also expressed concern regarding the health risks of fibrous minerals that are not currently regulated under MSHA's existing standards and suggested that MSHA conduct a new risk assessment to include them. MSHA considered these comments and determined that a new risk assessment is not necessary for this final rule, since fibrous minerals that are not currently regulated under MSHA's existing standards are beyond the scope of this rulemaking.

Some commenters stressed the lack of asbestos-related disease among miners in studies conducted at gold, taconite, and talc operations where there was asbestos contamination in the ore. In developing this final rule, MSHA considered a number of environmental and epidemiological studies conducted at mining operations. These studies demonstrated adverse health effects among miners consistent with exposure to asbestos in other workers. Researchers have found excessive incidence of asbestos-related disease in miners at a vermiculite mining operation.⁴³ Studies of talc miners have shown excess lung cancer and non-malignant respiratory disease.⁴⁴ Researchers are now studying excessive mesotheliomas among iron miners in northeastern Minnesota to determine the source of the asbestos exposure.

Section VI of this preamble contains a summary of MSHA's findings from applying OSHA's quantitative assessment of risk to the mining industry. MSHA's *Regulatory Economic Analysis* (REA) contains a more in-depth discussion of the Agency's methodology and conclusions. MSHA placed the REA in the rulemaking docket and posted it on the Asbestos Single Source Page at <http://www.msha.gov/asbestos/asbestos.htm>. MSHA also placed OSHA's risk assessment in its rulemaking docket.

C. Characterization of the Risk to Miners

After reviewing the evidence of adverse health effects associated with exposure to asbestos, MSHA evaluated that evidence to ascertain whether

exposure levels currently existing in mines warrant regulatory action. The criteria for this evaluation are established by the Federal Mine Safety and Health Act of 1977 (Mine Act) and related court decisions.⁴⁵

Section 101(a) of the Mine Act requires MSHA " * * * to develop, promulgate, and revise * * * improved mandatory health or safety standards for the protection of life and prevention of injuries in coal or other mines." Further, section 101(a)(6)(A) provides that—

The Secretary, in promulgating mandatory standards dealing with toxic materials or harmful physical agents under this subsection, shall set standards which most adequately assure on the basis of the best available evidence that no miner will suffer material impairment of health or functional capacity even if such miner has regular exposure to the hazards dealt with by such standard for the period of his working life.

Section 101(a)(6)(A) also requires that MSHA base its health and safety standards on " * * * the latest available scientific data in the field, the feasibility of the standards, and experience gained under this and other health and safety laws." As discussed in section VI.B, a 0.1 f/cc TWA PEL for asbestos is technologically and economically feasible.

Based on court interpretations of similar language under the Occupational Safety and Health Act, MSHA has addressed the following three questions:

(1) Do the health effects associated with asbestos exposure constitute a "material impairment" to miner health or functional capacity? Miners exposed to asbestos are at risk of developing lung cancer, mesotheliomas, and other cancers, as well as asbestosis and other nonmalignant respiratory diseases.⁴⁶ These health effects constitute a "material impairment of health or functional capacity."

(2) Are exposed miners at significant risk of incurring any of these material impairments? Based on OSHA's risk assessment, MSHA has determined that a significant health risk exists for miners exposed to asbestos at MSHA's existing 8-hour TWA PEL of 2 f/cc. Over a 45-year working life, exposure at this level can be expected to result in a 6.4 percent incidence of cancer (lung cancer, mesotheliomas, and gastrointestinal cancer) and a 5.0 percent incidence of asbestosis.

(3) Will this final rule substantially reduce such risks? By lowering the 8-

hour TWA PEL to 0.1 f/cc, MSHA will reduce the risk of asbestos-related cancers from 6.4 percent to 0.34 percent and the risk of asbestosis from 5.0 percent to 0.25 percent. MSHA considers this reduction to be substantial.

V. Section-by-Section Analysis of Final Rule

The final rule is substantively the same as the proposed rule. To make the standard easier to read, however, MSHA has divided the requirements in the final standards into three paragraphs: *Definitions*, *Permissible Exposure Limits (PELs)*, and *Measurement of Airborne Fiber Concentration*. For §§ 56/57.5001(b), the metal and nonmetal asbestos standards, MSHA designated the paragraphs (b)(1), (b)(2), and (b)(3). For § 71.702, the coal asbestos standard, MSHA designated the paragraphs (a), (b), and (c).

A. §§ 56/57.5001(b)(1) and 71.702(a): Definitions

The final rule, like the proposal, makes no substantive changes to the definition of asbestos in MSHA's existing standards. MSHA's existing definition of asbestos is consistent with the regulatory provisions of several Federal agencies including EPA, OSHA, and CPSC, among others. Asbestos is not a definitive mineral, but rather a generic name for a group of minerals with specific characteristics. MSHA's existing standards state that, "when crushed or processed, [asbestos] separates into flexible fibers made up of fibrils" [§§ 56/57.5001(b)]; and "does not include nonfibrous or nonasbestiform minerals" (§ 71.702). Although there are many asbestiform minerals,⁴⁷ the term asbestos in MSHA's existing standards and this final rule is limited to the following six:⁴⁸

- Chrysotile (serpentine asbestos, white asbestos).
- Cumingtonite-grunerite asbestos (amosite, brown asbestos).
- Crocidolite (riebeckite asbestos, blue asbestos).
- Anthophyllite asbestos (asbestiform anthophyllite).
- Tremolite asbestos (asbestiform tremolite).
- Actinolite asbestos (asbestiform actinolite).

Like the proposal, the final rule makes several clarifying changes to the existing regulatory language. They have no impact on the minerals that MSHA regulates as asbestos. This more precise

⁴³ Sullivan, 2007.

⁴⁴ NIOSH (HETA/MHETA), 1990; NIOSH (Technical Report), 1980.

⁴⁵ *Industrial Union Department, AFL-CIO v. American Petroleum Institute*, 448 U.S. 607, 100 S.Ct. 2844 (1980) ("Benzene case").

⁴⁶ American Thoracic Society, 2004; Delpierre *et al.*, 2002.

⁴⁷ Leake *et al.*, 1997; Meeker *et al.*, 2003.

⁴⁸ ATSDR, p.136, 2001; NIOSH Pocket Guide, 2003.

language will facilitate mine operators' understanding of the scope of the standard. This final asbestos rule—

- Clarifies that *cummingtonite-grunerite asbestos* is the mineralogical term for *amosite*, a trade name for asbestos from a specific geographical region;
- Clarifies that MSHA's definition of *fiber* for analytical purposes includes the same dimensional criteria as in the existing standards, which are consistent with OSHA's asbestos standard; and
- Clarifies the asbestos standard by inserting uniform structure and language.

Some commenters suggested that MSHA should expand its definition of asbestos to include other asbestiform minerals, so long as MSHA's analytical method excluded the counting of cleavage fragments. Another commenter asked that MSHA not include nonasbestiform fibrous minerals and mineral cleavage fragments when MSHA performs microscopic analyses of samples. Others supported the inclusion and regulation of asbestiform amphiboles that have shown or are likely to show asbestos-like health effects.

Many commenters did not want MSHA to make changes to the fibers regulated as asbestos in the existing standards. Specifically, they did not want MSHA to address other asbestiform amphiboles found in mineral deposits because there is no evidence that these fibers pose the same health problems that asbestos does. Some said that it would be unreasonable and expensive to try to meet exposure limits for all these other asbestiform minerals. Other commenters stated that, whatever they are called, asbestiform minerals cause illness.

As stated throughout this rulemaking, the final rule makes no substantive changes to the definition of asbestos in MSHA's existing standards. Such changes were not contemplated in the proposed rule and, therefore, are beyond the scope of this final rule.

B. Sections 56/57.5001(b)(2) and 71.702(b): Permissible Exposure Limits (PELs)

1. Sections 56/57.5001(b)(2)(i) and 71.702(b)(1): 8-Hour, Time-Weighted Average (TWA), Full-Shift Permissible Exposure Limit

The final rule adopts OSHA's 8-hour TWA PEL of 0.1 f/cc. No commenters objected to this aspect of the proposal.

Asbestos occurs naturally in many types of ore bodies and may be released from mine sites into the environment; but, MSHA's sampling results indicate that there is not widespread overexposure to asbestos in the mining industry at this time. MSHA's sampling data for 2000 through May 2007 show that 3 percent of MSHA's full-shift asbestos samples exceed OSHA's TWA PEL of 0.1 f/cc using a TEM-based analysis.

Commenters expressed concern about potential asbestos exposure of those living close to a mining operation. Although MSHA's reduction of its asbestos PELs may reduce environmental levels, other Federal, State, and local agencies have jurisdiction over environmental exposures.

2. Sections 56/57.5001(b)(2)(ii) and 71.702(b)(2): Excursion Limit

The final rule, like the proposal, adopts OSHA's excursion PEL of 1 f/cc as measured over 30 minutes. Some commenters were concerned that an excursion limit is not enforceable and, therefore, should be removed from the rule. Although MSHA may not always be present to take air samples to evaluate a miner's exposure during brief episodes of asbestos exposure, existing §§ 56/57.5002 and 71.701 require mine operators to conduct sampling to determine the need for, and effectiveness of, control measures when miners may be exposed to asbestos.

An excursion limit sets levels, not based on toxicological data, for peak episodes of exposure. As previously discussed, asbestos poses a long-term health risk to exposed workers. Although the final rule will substantially reduce the risk of asbestos-related deaths from a lifetime exposure, it does not completely eliminate this risk. The excursion limit will help reduce the long-term risk by addressing brief, episodic exposures. This type of episodic exposure can be foreseen and proactively controlled by the use of personal protective equipment (respirators and protective clothing) and by implementing engineering or work practice controls (glove boxes, tents, wet methods).

The final rule includes an excursion limit for asbestos to help maintain the average airborne concentration below the full-shift exposure limit. For example, for miners exposed to one 30-minute excursion per day at 1 f/cc, the

8-hour TWA airborne asbestos concentration would be 0.06 f/cc, which is less than the 0.1 f/cc 8-hour TWA PEL. For miners exposed to two 30-minute excursions per day at 1 f/cc, the 8-hour TWA airborne asbestos concentration would be 0.13 f/cc, which exceeds the 0.1 f/cc 8-hour TWA PEL.

One commenter urged MSHA to retain 15 minutes, rather than switch to 30 minutes, as the sampling period for enforcement of the excursion limit. As shown in Table V–1 below, the excursion limit of 1 f/cc for 30 minutes is the lowest concentration that MSHA can measure reliably for determining compliance with the excursion limit. MSHA recognizes that in some situations, such as low background dust levels, lower exposures could be measured by using a higher flow rate; but, the risk of overloading the filter with debris increases when using higher flow rates. MSHA can be confident that it is measuring the actual airborne concentrations of asbestos, within a standard sampling and analytical error (± 25 percent), when the Agency uses the minimum loading suggested by the OSHA Reference Method (29 CFR 1910.1001, Appendix A).

As discussed in OSHA's 1986 asbestos final rule (51 FR 22686), the key factor in sampling precision is fiber loading. To determine whether the analytical method described in Appendix A of its asbestos standard could be used to analyze short-term samples, OSHA calculated the lowest reliable limit of quantification using the following formula:

$$C = \{[f/[(n)(A_f)](A_c)]/[(V)(1,000)]\}$$

Where:

C = fiber concentration (in f/cc of air);

f = the total fiber count;

n = the number of microscope fields examined;

A_f = the field area (0.00785 mm²) for a properly calibrated Walton-Beckett graticule;

A_c = the effective area of the filter (in mm²); and

V = the sample volume (liters).

Table V–1 was generated from the above equation. The table shows that 1 f/cc measured over 30 minutes can be reliably measured when pumps are used at the higher flow rates of 1.6 Lpm or more, using 25-mm filters. The table also shows that MSHA cannot reliably measure 1 f/cc with 15-minute air samples, even when they are collected at the higher pump flow rates.

TABLE V-1.—RELATIONSHIP OF SAMPLING METHOD TO MEASUREMENT OF ASBESTOS

Sampling time and flow rate	Lowest level reliably measured using 25-mm filters
15 min at 2.5 Lpm	1.05 f/cc.
15 min at 2.0 Lpm	1.31 f/cc.
15 min at 1.6 Lpm	1.63 f/cc.
15 min at 1.0 Lpm	2.61 f/cc.
15 min at 0.5 Lpm	5.23 f/cc.
30 min at 2.5 Lpm	0.51 f/cc.
30 min at 2.0 Lpm	0.65 f/cc.
30 min at 1.6 Lpm	0.82 f/cc.
30 min at 1.0 Lpm	1.31 f/cc.
30 min at 0.5 Lpm	2.61 f/cc.

After evaluating the comments, MSHA retains the proposed asbestos excursion limit of 1 f/cc over a period of 30 minutes in the final rule.

C. Sections 56/57.5001(b)(3) and 71.702(c): Measurement of Airborne Fiber Concentrations

The final rule, like the proposed rule, requires an initial determination of fiber concentration using a PCM-based analytical method statistically equivalent to the OSHA Reference Method in OSHA's asbestos standard (29 CFR 1910.1001, Appendix A).

With respect to analytical methods, the final rule is substantively the same as MSHA's existing standards. PCM-based analytical methods were used in the development of past exposure assessments and risk estimates, and are relatively quick and cost-effective. OSHA used a PCM-based methodology as the defining basis of its asbestos risk assessment. PCM-based analytical methods remain the most practical way to evaluate asbestos exposures in mining. MSHA recognizes, however, that all analytical methods, including those used to identify and quantify the six asbestos minerals regulated by MSHA have limitations. Analysts have quantified the limits of detection, precision, and accuracy of these methods, termed "analytical error;" and MSHA includes this analytical error in evaluating asbestos exposures and enforcing the PELs. As discussed below, comments varied on MSHA's proposed sampling and analytical techniques. Most commenters supported a combination of PCM-based and TEM-based techniques for evaluating mine air samples.

1. Background of Analytical Method for Asbestos

Historically, asbestos samples have been analyzed by mass (weighing), counting (microscopy), or a qualitative property (spectroscopy). When recommending an exposure standard for chrysotile asbestos, the British

Occupational Hygiene Society said⁴⁹ that the microscopic counting of particles greater than 5 µm in length would show a relationship with the prevalence of asbestosis similar to those studies based on the mass of respirable asbestos. Many studies have suggested that counting only fibers longer than 5 µm minimizes variations between microscopy techniques⁵⁰ and improves the precision of the results.⁵¹ The scientific community accepted this length together with a minimum 3:1 length to diameter aspect ratio, as the counting criteria for asbestos fibers that provides an index of asbestos exposure, even though some believed that shorter fibers should be included due to their possible health effects.⁵² Acceptance of PCM-based methodology has served as the basis of asbestos risk assessments.

In recommending an asbestos standard in 1972 and 1976, NIOSH suggested using the same size criteria that the British adopted. They also recommended reevaluating these criteria when more definitive information on the biologic response and precise epidemiologic data are developed. NIOSH applied a conversion factor to exposure data not obtained using a PCM-based analytical method, to estimate what the exposure data would have been using a PCM-based method. This conversion allowed NIOSH to use non-PCM-based exposure data, together with PCM-based exposure data, in determining a recommended permissible exposure level.

2. MSHA's Analytical Methods for Enforcement of Its Asbestos PELs

Prior to 2001, OSHA analyzed MSHA's asbestos samples using OSHA ID-160, a PCM-based analytical method. Since 2001, MSHA has contracted with American Industrial Hygiene Association (AIHA) accredited

laboratories to analyze its asbestos samples using NIOSH's PCM-based analytical method, and to follow up with an analysis using NIOSH's TEM-based method when the PCM results indicate an exposure exceeding 0.1 f/cc. These commercial laboratories report analytical results as the fiber concentration (f/cc) for each filter analyzed.

Several factors complicate the evaluation of personal exposure levels in mining environments. For example, non-asbestos fibers and dust particles collected on the filter can obscure the asbestos fibers or overload the filter. Depending on the amount of visible dust in the air, MSHA's sampling procedures allow the setting of pump flow rates and consecutive sampling to minimize or eliminate mixed dust overload.

Commenters criticized MSHA's use of PCM-based methods to evaluate asbestos exposures. Several recommended that MSHA adopt a new ASTM method (ASTM D 7200-06), which references the characteristics of asbestiform fibers in EPA's bulk sample method.⁵³ Many recommended that MSHA not conduct air sampling unless prior bulk sampling had identified asbestos fibers. Some commenters recommended that the final rule include a TEM-based analytical method for the initial determination of compliance.

Bulk sampling presents limitations. The presence of asbestos in a bulk sample does not mean that it poses a hazard. The asbestos must become airborne and be respirable, or contaminate food or water, to pose a health hazard to miners. Analysis of bulk samples is usually performed using polarized light microscopy (PLM). A particle must be at least 0.5 µm in diameter to refract light and many asbestos fibers are too thin to refract light. Asbestos may be a small percentage of the parent material or not uniformly dispersed in the sample and,

⁴⁹ Lane *et al.*, 1968.

⁵⁰ ACGIH-AIHA, 1975.

⁵¹ Wylie, 2000.

⁵² ACGIH-AIHA, 1975; NIOSH, 1972.

⁵³ ASTM, 2006; EPA, 1993.

therefore, may not be seen in the small portion of sample that is examined under the microscope. Another problem with identifying asbestos using PLM is that both the asbestiform and nonasbestiform varieties of a mineral show the same refractive index. Although a trained individual may be able to identify bulk asbestos by its appearance and physical properties, the identification can be difficult when the asbestos is dispersed in a dust sample or is present in low concentration in a rock.

Due to a lack of consensus in the regulatory and scientific communities, revisions to MSHA's use of PCM-based analytical methods were not included within the scope of this rulemaking. If PCM-based analysis reveals a potential overexposure, MSHA will perform a TEM-based analysis to confirm asbestos exposure levels. Further, MSHA will consider the use of alternative analytical methods for the measurement of airborne asbestos that meet the analytical equivalency criteria for OSHA's Reference Method once they are recognized by a laboratory accreditation organization. For example, NIOSH is supporting an ASTM inter-laboratory study to validate whether ASTM D7200-06, "Standard Practice for Sampling and Counting Airborne Fibers, Including Asbestos Fibers, in Mines and Quarries, by Phase Contrast Microscopy and Transmission Electron Microscopy" can meet the OSHA equivalency criteria and be accredited.

a. Discussion of Microscope Properties.

One issue commenters mentioned concerning PCM-based analytical methods is the limited resolution and magnification of light microscopes compared to electron microscopes. The resolution of the microscope is the smallest separation between two objects that will allow them to be distinctly visible. The higher the resolving power of a microscope, the smaller the distance can be between two particles and have them still appear as two distinct particles. Resolution is about 0.2 μm using PCM compared with 0.0002 μm using TEM. This means that an analyst who sees a single fiber using PCM may see a number of thinner fibers using TEM. Individual fibrils of chrysotile are about 0.05 μm in diameter while amphibole fibrils are about 0.1 μm in diameter. Using TEM, the analyst is able to see thinner fibers and, therefore, should be able to see more fibers than when using PCM.

Magnification is the ratio of the size that the object appears under the microscope to its actual size. A PCM-based analysis of air samples for

asbestos typically uses a magnification of 400 to 450 times (\times) the object's actual size. In contrast, a TEM-based analysis typically uses a magnification of 10,000 \times . As a result, an analyst using PCM sees a larger amount of the sample than one using TEM, although in less detail.

b. Variability in Counting Asbestos Fibers Using PCM.

Commenters generally supported MSHA's use of a PCM-based analytical method for the initial analysis of fiber samples for determining compliance. One of the commenters' major concerns focused on the variability of fiber counting procedures. MSHA understands that the PCM-based analytical methods yield considerable variability in counting fibers because it is dependent on a number of related variables, such as the optical performance of the microscope, the optical properties of the prepared sample, and the proportion of fine particles.⁵⁴

OSHA recognized the variability of using a PCM-based analytical method in its rulemaking. The requirements listed at 29 CFR 1910.1001 Appendix A minimize the effect of the known variability by describing the essential steps of a generic sampling and analytical procedure. OSHA also established criteria to limit variability. Subsequently, other papers have addressed variability issues related to PCM counting techniques.⁵⁵

Commenters suggested a number of techniques to reduce the variability in counting fibers on mine air samples. Some asked that MSHA consider respirable or thoracic sampling to minimize interference from large particles that can obscure asbestos fibers on the filter. Some supported a counting technique based on the typical characteristics of asbestos in air. Others recommended using a higher aspect ratio to increase the probability that the structures counted are fibers. Another commenter stated that several approaches have been tried to remove non-asbestos minerals from samples, such as low temperature ashing or dissolution, but these approaches are not useful for mining samples. Many commenters suggested the development of differential counting techniques that consider the fiber morphology and the distributions or populations of distinct fiber groups with characteristic dimensions to analyze mine air samples for fibers. Other commenters stated that particle characteristics could not be used reliably to differentiate fibers from

cleavage fragments when examining relatively small numbers of fibers. Several commenters suggested the development of a new analytical method for asbestos in mine air samples.

Much of the variability in counting asbestos is attributed to the visual acuity of the analyst in observing and sizing fibers and in interpreting the counting rules.⁵⁶ Overall, commenters recognized that it takes far less time to develop expertise in counting fibers using PCM than in developing expertise using TEM. NIOSH has developed a 40-hour training course for analysts as an adequate prerequisite to conducting total fiber counts using PCM. To differentially count asbestos fibers, an analyst must have advanced knowledge of mineralogy and expertise in the microscopic techniques used. This knowledge and expertise can be gained only by years of experience counting fiber samples collected in a variety of environments.

The availability of analyst training courses, and the formation of accreditation bodies requiring laboratory quality assurance programs, helps minimize the variations in measurements between and within laboratories.⁵⁷ Accreditation bodies require laboratories to use standardized analytical methods. AIHA has the Asbestos Analyst Registry that specifies criteria for competence, education, and performance for analysts. In addition to these programs, MSHA's incorporation of OSHA's Appendix A helps minimize the subjectivity and increase consistency of measuring airborne asbestos concentrations by specifying core elements of an acceptable PCM-based analytical method.

3. MSHA's Incorporation of Appendix A of OSHA's Asbestos Standard

MSHA's existing standards include basic elements of PCM-based analytical methods. These same basic elements for asbestos exposure monitoring are included in the OSHA Reference Method in Appendix A of OSHA's asbestos standard. The evaluation or inclusion of methods that do not include these basic elements or that deviate from the criteria for counting fibers in MSHA's existing standards was not contemplated in the proposed rule and, therefore, is beyond the scope of this final rule.

OSHA's Appendix A, the OSHA Reference Method (ORM), specifies the elements of an acceptable analytical method for asbestos and the quality

⁵⁴ Rooker *et al.*, 1982.

⁵⁵ Pang, 2000; Harper and Bartolucci, 2003.

⁵⁶ Rooker *et al.*, 1982.

⁵⁷ Schlect and Shulman, 1995.

control procedures that laboratories performing the analysis must implement. To encourage innovation and technological advancement, the final rule allows for MSHA's acceptance of other analytical methods that are at least as effective in identifying potential asbestos overexposures as the OSHA Reference Method (29 CFR 1910.1001, Appendix A). MSHA considers the counting criteria for a fiber in the OSHA Reference Method to be statistically equivalent to that in MSHA's definition of a fiber.

For the purpose of this final rule, MSHA considers a method to be statistically equivalent to the ORM and at least as effective as MSHA's existing method if it meets the following criteria from 29 CFR 1910.1001(d)(6)(iii):

(A) Replicate exposure data used to establish equivalency are collected in side-by-side field and laboratory comparisons; and

(B) The comparison indicates that 90% of the samples collected in the range 0.5 to 2.0 times the permissible limit have an accuracy range of plus or minus 25 percent of the ORM results at a 95% confidence level as demonstrated by a statistically valid protocol; and

(C) The equivalent method is documented and the results of the comparison testing are maintained.

Although MSHA can calculate concentrations below 0.1 f/cc, neither NIOSH 7400 nor OSHA ID 160 sampling and analytical methods obtain statistically reliable, repeatable measurements within ± 25 percent of the mean with 95 percent confidence for concentrations lower than 0.1 f/cc. The preamble to OSHA's 1994 asbestos rule (59 FR 40967) states that 0.1 f/cc is "the practical lower limit of feasibility for measuring asbestos levels reliably."

Appendix A lists NIOSH 7400 and OSHA ID-160 as analytical methods that meet these equivalency criteria. MSHA will consider other analytical methods that afford an equivalent measurement alternative as they become available.

4. Epidemiological Studies and Health Risk Data Based on PCM Analytical Methods

A number of commenters pointed out that a PCM-based methodology counts more than asbestos. These commenters suggested that the lower risk seen in epidemiological studies relating PCM-based exposure estimates to adverse health outcomes in miners was due to the other material inherent in air samples taken in a mining environment. They speculated that non-asbestos dust particles had been counted and included in the estimated

concentrations, which would have overestimated asbestos exposures. MSHA acknowledges the possible overestimation of asbestos-related disease in applying OSHA's risk assessment to mining exposures based solely on PCM analytical results. For this reason, by policy, MSHA uses a subsequent TEM analysis to identify asbestos minerals and minimize this overestimation when determining asbestos exposures. MSHA has not found sufficient information to make a "differential risk" determination for the mining industry within OSHA's quantitative risk assessment, which MSHA uses as the basis for this final rule.

5. Discussion of Cleavage Fragments and Non-Asbestos Minerals

During this rulemaking, MSHA has received many comments regarding cleavage fragments. MSHA has not addressed cleavage fragments in this final rule. To do so would require a change in both the analytical method and the definition of asbestos, neither of which were contemplated in the proposed rule and are, therefore, beyond the scope of this final rule. The final rule retains MSHA's PCM-based analytical method. To minimize the impact of cleavage fragments on sampling results, however, MSHA will continue its policy of conducting a subsequent TEM-based analysis on samples with PCM results that exceed the PEL.

Many commenters expressed concern that standard phase contrast counting techniques are not specific in determining exposure to only the six Federal asbestos minerals and may misidentify cleavage fragments as asbestos fibers. PCM-based analytical methods do not distinguish between asbestos and any other fiber meeting the size and aspect ratio criteria. A number of commenters highlighted the seeming contradiction between MSHA's stated intent to exclude cleavage fragments from the standard and the Agency's selection of a PCM-based analytical method that may identify elongated amphibole cleavage fragments as asbestos fibers.

Commenters suggested several ways to eliminate cleavage fragments. For example, some suggested that MSHA use a revised PCM-based method with differential counting criteria that referenced OSHA's 29 CFR 1910.1001 Appendices B and C.⁵⁸ Others suggested

⁵⁸ Appendix B (non-mandatory) is a detailed procedure for asbestos sampling and analysis. OSHA removed Appendix C (mandatory), which specified qualitative and quantitative fit testing

a proposed ASTM method, which was adopted in June 2006 (ASTM D 7200-06). Several recommended a fiber population analysis that examined samples for the characteristics of commercial asbestos listed in Appendix A of EPA's *Method for the Determination of Asbestos in Bulk Building Materials* (EPA, 1993).

MSHA acknowledges that PCM-based analytical methods for the quantitative analysis of asbestos samples have some limitations, especially if samples are collected in a mixed dust environment. PCM-based analysis, however, addresses the key problem of needing to make a relatively fast, cost-effective evaluation of miners' work environments so as to improve their health protection. Using a PCM-based analytical method maintains the usefulness of the analytical results relative to the historic health data.⁵⁹ When an exposure exceeds the full-shift or excursion PEL, MSHA uses a TEM-based method to confirm the presence of asbestos.

D. § 71.701(c) and (d): Sampling; General Requirements (Controlling Asbestos Exposures in Coal Mines)

This final rule retains the proposed revision to add a reference to § 71.702 in paragraphs (c) and (d) of § 71.701 to clarify MSHA's intent that coal mine operators control miners' exposures to asbestos. MSHA received no substantive comments on this proposed change.

VI. Regulatory Analyses

A. Executive Order (E.O.) 12866

Executive Order (E.O.) 12866 (58 FR 51735) as amended by E.O. 13258 (Amending Executive Order 12866 on Regulatory Planning and Review (67 FR 9385)) requires regulatory agencies to assess both the costs and benefits of regulations. To comply with Executive Order 12866, MSHA has prepared a Regulatory Economic Analysis (REA) for this final rule. The REA contains supporting data and explanation for the summary materials presented in section VI of this preamble, including the covered mining industry, costs and benefits, feasibility, and small business impact. The REA is located on MSHA's Web site at <http://www.msha.gov/regsinfo.htm>. A copy of the REA can be obtained from MSHA's Office of Standards, Regulations, and Variances.

Executive Order 12866 classifies a rule as a significant regulatory action

procedures, when they promulgated their respiratory protection standard (29 CFR 1910.134). Given the context of the comment, MSHA thinks the commenter may have been referring to Appendix J, OSHA's PLM analytical method.

⁵⁹ Wylie *et al.*, 1985.

requiring review by the Office of Management and Budget if it has an annual effect on the economy of \$100 million or more; creates a serious inconsistency or interferes with an action of another agency; materially alters the budgetary impact of entitlements or the rights of entitlement recipients; or raises novel legal or policy issues. MSHA has determined that the final rule would not have an annual effect of \$100 million or more on the economy and, therefore, it is not an economically "significant regulatory action" pursuant to section 3(f) of E.O. 12866. MSHA, however, has concluded that the proposed rule is otherwise significant under Executive Order 12866 because it raises novel legal or policy issues.

1. Discussion of Benefits

This final rule will reduce diseases arising from exposure to asbestos, and the associated costs to employers, miners' families, and society at large. Exposure to asbestos can cause lung cancer; mesothelioma; gastrointestinal cancer; cancers of the larynx, pharynx, and kidneys; asbestosis; and other respiratory diseases. Reduced miners' exposures will reduce adverse health effects both in terms of the incidence of disease affecting quality of life, and deaths from both cancer and non-cancer disease. These asbestos-related diseases cause a material impairment of human health or functional capacity.

This benefit analysis quantifies the reduction in expected deaths to miners resulting from reduced exposure to airborne asbestos. The benefit is a result of reducing the 8-hour time-weighted average (TWA) permissible exposure limit (PEL) from 2 fibers per cubic centimeter (f/cc) to 0.1 f/cc. MSHA acknowledges that this change will not eliminate the risk of asbestos-related material impairment of health. (See Table IV-1.)

a. Summary of Benefits.

By lowering the PEL to 0.1 f/cc, MSHA estimates the prevention of one occupationally related cancer death caused by asbestos exposure over the 55-year period beginning 10 years after implementation of the final rule. MSHA estimates that there will be benefits resulting from lowering the excursion limit, but is unable to quantify these benefits. This analysis underestimates the total benefits of the rule by quantifying only the cancer deaths prevented. The benefits do not include the reduced incidence of asbestosis-related disabilities.

b. Calculation of Premature Deaths Prevented.

MSHA limits the quantified benefits to an estimation of the number of cancer cases prevented. MSHA expresses the results as "deaths prevented" because the cancers associated with asbestos exposure almost always result in premature death.

The benefits resulting from a reduction in the PEL depend on several factors including—

- Existing and projected exposure levels,
- Risk associated with each exposure level,
- Number of workers exposed at each exposure level, and
- Age of the miner at first exposure.

MSHA estimated the number of miners currently exposed and their levels of exposure from data on personal exposure sampling during regular and special inspections between January 2000 and May 2007. These data are available on MSHA's Web site at <http://www.msha.gov>. Section III of this preamble contains the characterization and assessment of exposures in mining.

Laboratory results indicate that exposure concentrations are unevenly distributed across mines and among miners within mines. MSHA uses four fiber concentration levels to estimate the risk to miners. The break points for these exposure levels are the existing and final exposure limits as follows: Less than 0.1 f/cc, 0.1 to less than 1 f/cc, 1 f/cc to less than 2 f/cc, and 2 f/cc or greater. Approximately 86 percent of MSHA's PCM-based fiber sampling results are below 0.1 f/cc. Approximately 97 percent of MSHA's TEM-based asbestos sampling results are below 0.1 f/cc. Based on MSHA's sampling data, concentrations ranged between 0.0 and 38.1 f/cc over these years. The highest concentration level in Table IV-1 is 10 f/cc. MSHA's calculations, therefore, use an upper exposure limit of 10 f/cc. Samples with exposure concentrations above 10 f/cc are included in this benefits analysis as 10 f/cc. MSHA's estimated benefits derive totally from the mines MSHA has sampled.

MSHA applied OSHA's linear, no-threshold, dose-response risk assessment model to MSHA's existing PEL and final PEL to estimate the expected number of asbestos-related deaths. The expected reduction of deaths resulting from lowering the PEL will be the difference between the expected deaths at 2 f/cc and 0.1 f/cc.⁶⁰ MSHA then applied these rates to the estimated number of miners exposed at

the corresponding concentration based on MSHA sampling data. The result is an estimate of miners' deaths resulting from cancer due to occupational exposure to asbestos under existing exposure conditions.

c. Benefits of the 0.1 f/cc PEL.

Deaths from lung cancer, mesotheliomas, gastrointestinal cancer, and asbestosis are the result of past exposures to much higher air concentrations of asbestos than those found in mines today. The risks of these diseases still exist, however, and these risks are significant for miners exposed to lower air concentrations of asbestos. Most diseases resulting from a more recent asbestos exposure may not become evident for another 20 to 30 years. When the results of TEM analysis are incorporated into the exposure data, MSHA estimated a reduction of one cancer death (per 314 miners exposed above 0.1 f/cc, or 5 per 1,000 exposed) over a 55-year period starting 10 years after implementation of the lower 8-hour TWA PEL. This represents a 12 percent reduction in the miners' asbestos-related deaths that would be expected if existing exposures were to continue. The rate at which the incidence of the cancers decreases depends on several factors including—

- Latency of onset of cancer,
- Attrition of the mining workforce,
- Changing rates of competing causes of death,
- Dynamics of other risk factors,
- Changes in life expectancy, and
- Advances in cancer treatments.

d. Benefits of the 1 f/cc Excursion Limit.

The intended effect of the excursion limit is to protect miners from the adverse health risks associated with brief fiber releases. MSHA believes that miners will be exposed to brief fiber releases even when airborne concentrations of asbestos do not exceed the PEL. For example, mechanics may be inadvertently exposed to airborne asbestos while working on older equipment that may have asbestos-containing parts. Miners may encounter brief fiber releases while drilling, dozing, blasting, or roof bolting in areas of naturally occurring asbestos. These short-term exposures can easily be above 1 f/cc; however, when averaged over an 8-hour shift, they fall within the 0.1 f/cc PEL. However, because MSHA does not have sufficient data regarding the relationship between the frequency of brief fiber releases and adverse health risks, this analysis demonstrates the theoretical benefits from limiting short-term exposures to the excursion limit.

This section estimates the benefits of the excursion limit of 1 f/cc for one 30-

⁶⁰Nicholson, 1983; JRB Associates, 1983; OSHA (51 FR 22612), 1986; OSHA (53 FR 35609), 1988; OSHA (59 FR 40964), 1994.

minute period per day. Two 30-minute exposures per day at 1 f/cc will exceed the 8-hour TWA, full shift exposure limit (i.e., 1 f/cc for 48 minutes = 0.1 f/cc for 480 minutes).

MSHA estimates the benefit of an excursion limit from the difference in concentration between the PEL and the excursion limit averaged over the full shift $[(1 \text{ f/cc})/(16 \text{ 30-minute periods}) = 0.063 \text{ f/cc}]$. The lifetime risk associated with an exposure to 0.1 f/cc is 0.00336, if first exposed at age 25 and exposure continues every work day at that level

for 45 years. The risk associated with exposure to 0.063 f/cc using the same age and duration of exposure is 0.00212. The difference in lifetime risk is 0.00124, which equates to one additional premature death prevented for every 1,000 miners exposed to asbestos above the 1 f/cc excursion limit.

2. Discussion of Costs

The final rule will result in total costs of approximately \$201,000 per year for all mines. The cost will be approximately \$156,000 for metal and

nonmetal mines and approximately \$45,000 for coal mines. These costs represent less than 0.001 percent of the yearly revenues of \$64.4 billion for the metal and nonmetal mining industry and \$27.0 billion for the coal mining industry.

Table VI–1 presents MSHA's estimate of the total yearly compliance costs by compliance strategy and mine size. The total costs reported are projected costs, in 2006 dollars, based on MSHA's knowledge, experience, and available information.

TABLE VI–1.—SUMMARY OF YEARLY COMPLIANCE COSTS

Metal and nonmetal mine size	Compliance strategy				Total for metal and nonmetal mines
	Selective mining	Wet methods	Ventilation	Removal of ACM	
1–19	\$2,417	\$2,820	\$1,619	\$1,750	\$8,606
20–500	11,242	19,673	28,048	21,000	79,962
501+	3,747	6,558	41,278	15,750	67,333
Total	17,406	29,050	70,945	38,500	155,901

Coal mine size	Compliance strategy				Total for coal mines
	Selective mining	Wet methods	Ventilation	Removal of ACM	
1–19	\$875	\$875
20–500	12,250	12,250
501+	31,500	31,500
Total	44,625	44,625

B. Feasibility

MSHA has determined that the requirements of this final rule are both technologically and economically feasible.

In the discussion of PELs in section V.B of this preamble, MSHA stated that there is a residual risk of adverse health effects for miners exposed at the PEL. MSHA considered proposing a lower PEL as a regulatory alternative to further reduce the risk of adverse health effects from a working lifetime of exposure. When OSHA reduced the PEL from 0.2 to 0.1 f/cc in 1994, OSHA concluded that this concentration is “the practical lower limit of feasibility for measuring asbestos levels reliably.” (59 FR 40967) About 85 percent of the sampled mines are already in compliance with the 0.1 f/cc PEL.

This final rule is not a technology-forcing standard. All equipment required by the final rule and a variety of dust control strategies and control methods are already available in the marketplace and have been used successfully by the U.S. mining community to control asbestos exposures. MSHA has concluded that this final rule is technologically feasible.

The mining industry would incur costs of about \$201,000 yearly to comply with this final rule. These compliance costs represent less than 0.001 percent of the yearly revenues of the mines covered by this rule (approximately \$64.4 billion for metal and nonmetal and \$27.0 billion for coal). MSHA has concluded that this final rule is economically feasible.

D. Regulatory Flexibility Analysis (RFA) and Small Business Regulatory Enforcement Fairness Act (SBREFA)

Based on MSHA's data and experience, and information submitted to the record, the Agency has determined and here certifies that this final rule will not have a significant economic impact on a substantial number of small entities. The REA for this final rule (RIN: 1219–AB24), *Asbestos Exposure Limit*, contains the factual basis for this certification as well as complete details about data, equations, and methods used to calculate the costs and benefits. MSHA has placed the REA in the rulemaking docket and posted it on MSHA's Web site at <http://www.msha.gov>.

E. Other Regulatory Considerations

1. The National Environmental Policy Act of 1969 (NEPA)

MSHA has reviewed the final rule in accordance with the requirements of NEPA of 1969 (42 U.S.C. 4321 *et seq.*), the regulations of the Council on Environmental Quality (40 CFR part 1500), and the Department of Labor's NEPA procedures (29 CFR part 11) and has assessed the environmental impacts. The Agency found that the final rule will have no significant impact on air, water, or soil quality; plant or animal life; the use of land; or other aspects of the human environment.

2. Paperwork Reduction Act of 1995

The final rule contains no information collection or recordkeeping requirements. Thus, there are no additional paperwork burden hours and related costs associated with the final rule. Accordingly, the Paperwork Reduction Act requires no further agency action or analysis.

3. The Unfunded Mandates Reform Act of 1995

MSHA has reviewed the final rule under the Unfunded Mandates Reform

Act of 1995 (2 U.S.C. 1501 *et seq.*). MSHA has determined that the final rule does not include any Federal mandate that may result in increased expenditures by State, local, or tribal governments; nor does it increase private sector expenditures by more than \$100 million in any one year or significantly or uniquely affect small governments. Accordingly, the Unfunded Mandates Reform Act of 1995 (2 U.S.C. 1501 *et seq.*) requires no further agency action or analysis.

4. Treasury and General Government Appropriations Act of 1999 (Section 654: Assessment of Impact of Federal Regulations and Policies on Families)

Section 654 of the Treasury and General Government Appropriations Act of 1999 (5 U.S.C. 601 note) requires agencies to assess the impact of Agency action on family well-being. MSHA has determined that the final rule will have no effect on family stability or safety, marital commitment, parental rights and authority, or income or poverty of families and children. Accordingly, MSHA certifies that the final rule will not impact family well-being.

5. Executive Order 12630: Government Actions and Interference with Constitutionally Protected Property Rights

The final rule does not implement a policy with takings implications. Accordingly, E.O. 12630 requires no further Agency action or analysis.

6. Executive Order 12988: Civil Justice Reform

The final rule was written to provide a clear legal standard for affected conduct and was carefully reviewed to eliminate drafting errors and ambiguities, so as to minimize litigation and undue burden on the Federal court system. Accordingly, the final rule meets the applicable standards provided in section 3 of E.O. 12988, Civil Justice Reform.

7. Executive Order 13045: Protection of Children from Environmental Health Risks and Safety Risks

The final rule has no adverse impact on children. Accordingly, under E.O. 13045, no further Agency action or analysis is required.

8. Executive Order 13132: Federalism

The final rule does not have “federalism implications,” because it does not “have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.”

Accordingly, Executive Order 13132, Federalism, requires no further agency action or analysis.

9. Executive Order 13175: Consultation and Coordination with Indian Tribal Governments

The final rule does not have “tribal implications,” because it does not “have substantial direct effects on one or more Indian tribes, on the relationship between the Federal government and Indian tribes, or on the distribution of power and responsibilities between the Federal government and Indian tribes.” Accordingly, under E.O. 13175, no further Agency action or analysis is required.

10. Executive Order 13211: Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use

Executive Order 13211 requires agencies to publish a statement of energy effects when a rule has a significant energy action that adversely affects energy supply, distribution or use. MSHA has reviewed the final rule for its energy effects because the final rule applies to the coal mining sector. MSHA has concluded that the final rule is not a significant energy action because it will not have significant adverse effect on the supply, distribution, or use of energy. Further, because the final rule will result in yearly costs of approximately \$45,000 to the coal mining industry, relative to annual revenues of \$27.0 billion in 2006, it is not a significant energy action because it is not likely to have a significant adverse effect on the supply, distribution, or use of energy. Accordingly, under this analysis, no further Agency action or analysis is required.

11. Executive Order 13272: Proper Consideration of Small Entities in Agency Rulemaking

MSHA has thoroughly reviewed the final rule to assess and take appropriate account of its potential impact on small businesses, small governmental jurisdictions, and small organizations. As discussed in section VI.D of this preamble, MSHA has determined and certified that the final rule would not have a significant economic impact on a substantial number of small entities. Accordingly, Executive Order 13272, Proper Consideration of Small Entities in Agency Rulemaking, requires no further agency action or analysis.

VII. Copy of the OSHA Reference Method (ORM)

MSHA’s existing asbestos standards require that the analyst determine fiber concentrations using a phase contrast microscopy analytical method with 400–450X magnification. The ORM contains these requirements. The definition of fiber in MSHA’s final rule includes the same characteristics as in the existing standards, i.e., longer than 5 µm with a length to width ratio of at least 3:1. Although the ORM requires counting fibers 5 µm or longer, there is no practical difference between these criteria considering the accuracy and precision of the analytical methods. NIOSH Method 7400 is equivalent to the ORM even though it requires counting fibers longer than 5 µm. The ORM also requires that analysts “* * * must have taken the NIOSH course for sampling and evaluating airborne asbestos dust or an equivalent course.”

29 CFR 1910.1001 Appendix A: OSHA Reference Method—Mandatory

This mandatory appendix specifies the procedure for analyzing air samples for asbestos and specifies quality control procedures that must be implemented by laboratories performing the analysis. The sampling and analytical methods described below represent the elements of the available monitoring methods (such as Appendix B of their regulation, the most current version of the OSHA method ID-160, or the most current version of the NIOSH Method 7400). All employers who are required to conduct air monitoring under paragraph (d) of the [OSHA] standard are required to utilize analytical laboratories that use this procedure, or an equivalent method, for collecting and analyzing samples.

Sampling and Analytical Procedure.

1. The sampling medium for air samples shall be mixed cellulose ester filter membranes. These shall be designated by the manufacturer as suitable for asbestos counting. See below for rejection of blanks.

2. The preferred collection device shall be the 25-mm diameter cassette with an open-faced 50-mm electrically conductive extension cowl. The 37-mm cassette may be used if necessary but only if written justification for the need to use the 37-mm filter cassette accompanies the sample results in the employee’s exposure monitoring record. Do not reuse or reload cassettes for asbestos sample collection.

3. An air flow rate between 0.5 liter/min and 2.5 liters/min shall be selected for the 25-mm cassette. If the 37-mm cassette is used, an air flow rate between 1 liter/min and 2.5 liters/min shall be selected.

4. Where possible, a sufficient air volume for each air sample shall be collected to yield between 100 and 1,300 fibers per square millimeter on the membrane filter. If a filter darkens in appearance or if loose dust is seen on the filter, a second sample shall be started.

5. Ship the samples in a rigid container with sufficient packing material to prevent

dislodging the collected fibers. Packing material that has a high electrostatic charge on its surface (e.g., expanded polystyrene) cannot be used because such material can cause loss of fibers to the sides of the cassette.

6. Calibrate each personal sampling pump before and after use with a representative filter cassette installed between the pump and the calibration devices.

7. Personal samples shall be taken in the "breathing zone" of the employee (i.e., attached to or near the collar or lapel near the worker's face).

8. Fiber counts shall be made by positive phase contrast using a microscope with an 8 to 10 × eyepiece and a 40 to 45 × objective for a total magnification of approximately 400 × and a numerical aperture of 0.65 to 0.75. The microscope shall also be fitted with a green or blue filter.

9. The microscope shall be fitted with a Walton-Beckett eyepiece graticule calibrated for a field diameter of 100 micrometers (±2 micrometers).

10. The phase-shift detection limit of the microscope shall be about 3 degrees measured using the HSE phase shift test slide as outlined below.

a. Place the test slide on the microscope stage and center it under the phase objective.

b. Bring the blocks of grooved lines into focus.

Note: The slide consists of seven sets of grooved lines (ca. 20 grooves to each block) in descending order of visibility from sets 1 to 7, 7 being the least visible. The requirements for asbestos counting are that the microscope optics must resolve the grooved lines in set 3 completely, although they may appear somewhat faint, and that the grooved lines in sets 6 and 7 must be invisible. Sets 4 and 5 must be at least partially visible but may vary slightly in visibility between microscopes. A microscope that fails to meet these requirements has either too low or too high a resolution to be used for asbestos counting.

c. If the image deteriorates, clean and adjust the microscope optics. If the problem persists, consult the microscope manufacturer.

11. Each set of samples taken will include 10 percent blanks or a minimum of 2 field blanks. These blanks must come from the same lot as the filters used for sample collection. The field blank results shall be averaged and subtracted from the analytical results before reporting. A set consists of any sample or group of samples for which an evaluation for this standard must be made. Any samples represented by a field blank having a fiber count in excess of the detection limit of the method being used shall be rejected.

12. The samples shall be mounted by the acetone/triacetin method or a method with an equivalent index of refraction and similar clarity.

13. Observe the following counting rules.

a. Count only fibers equal to or longer than 5 micrometers. Measure the length of curved fibers along the curve.

b. In the absence of other information, count all particles as asbestos that have a length-to-width ratio (aspect ratio) of 3:1 or greater.

c. Fibers lying entirely within the boundary of the Walton-Beckett graticule field shall receive a count of 1. Fibers crossing the boundary once, having one end within the circle, shall receive the count of one half (½). Do not count any fiber that crosses the graticule boundary more than once. Reject and do not count any other fibers even though they may be visible outside the graticule area.

d. Count bundles of fibers as one fiber unless individual fibers can be identified by observing both ends of an individual fiber.

e. Count enough graticule fields to yield 100 fibers. Count a minimum of 20 fields; stop counting at 100 fields regardless of fiber count.

14. Blind recounts shall be conducted at the rate of 10 percent.

Quality Control Procedures.

1. *Intralaboratory program.* Each laboratory and/or each company with more than one microscopist counting slides shall establish a statistically designed quality assurance program involving blind recounts and comparisons between microscopists to monitor the variability of counting by each microscopist and between microscopists. In a company with more than one laboratory, the program shall include all laboratories and shall also evaluate the laboratory-to-laboratory variability.

2. *Interlaboratory program.*

a. Each laboratory analyzing asbestos samples for compliance determination shall implement an interlaboratory quality assurance program that as a minimum includes participation of at least two other independent laboratories. Each laboratory shall participate in round robin testing at least once every 6 months with at least all the other laboratories in its interlaboratory quality assurance group. Each laboratory shall submit slides typical of its own work load for use in this program. The round robin shall be designed and results analyzed using appropriate statistical methodology.

b. All laboratories should also participate in a national sample testing scheme such as the Proficiency Analytical Testing Program (PAT), or the Asbestos Registry sponsored by the American Industrial Hygiene Association (AIHA).

3. All individuals performing asbestos analysis must have taken the NIOSH course for sampling and evaluating airborne asbestos dust or an equivalent course.

4. When the use of different microscopes contributes to differences between counters and laboratories, the effect of the different microscope shall be evaluated and the microscope shall be replaced, as necessary.

5. Current results of these quality assurance programs shall be posted in each laboratory to keep the microscopists informed.

[57 FR 24330, June 8, 1992; 59 FR 40964, Aug. 10, 1994]

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List of Subjects

30 CFR Parts 56 and 57

Air quality, Asbestos, Chemicals, Hazardous substances, Metals, Mine safety and health.

30 CFR Part 71

Air quality, Asbestos, Chemicals, Coal mining, Hazardous substances, Mine safety and health.

Dated: February 22, 2008.

Richard E. Stickler,
Acting Assistant Secretary for Mine Safety and Health.

■ For the reasons set out in the preamble, and under the authority of the

Federal Mine Safety and Health Act of 1977, MSHA is amending chapter I of title 30 of the Code of Federal Regulations as follows.

PART 56—SAFETY AND HEALTH STANDARDS—SURFACE METAL AND NONMETAL MINES

■ 1. The authority citation for part 56 continues to read as follows:

Authority: 30 U.S.C. 811.

■ 2. Section 56.5001 is amended by revising paragraph (b) to read as follows:

§ 56.5001 Exposure limits for airborne contaminants.

* * * * *

(b) *Asbestos standard*—(1) *Definitions.* Asbestos is a generic term for a number of hydrated silicates that, when crushed or processed, separate into flexible fibers made up of fibrils. As used in this part—

Asbestos means chrysotile, cummingtonite-grunerite asbestos (amosite), crocidolite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos.

Fiber means a particle longer than 5 micrometers (µm) with a length-to-diameter ratio of at least 3-to-1.

(2) *Permissible Exposure Limits (PELs)*—(i) *Full-shift limit.* A miner's personal exposure to asbestos shall not exceed an 8-hour time-weighted average full-shift airborne concentration of 0.1 fiber per cubic centimeter of air (f/cc).

(ii) *Excursion limit.* No miner shall be exposed at any time to airborne concentrations of asbestos in excess of 1 fiber per cubic centimeter of air (f/cc) as averaged over a sampling period of 30 minutes.

(3) *Measurement of airborne fiber concentration.* Fiber concentration shall be determined by phase contrast microscopy using a method statistically equivalent to the OSHA Reference Method in OSHA's asbestos standard found in 29 CFR 1910.1001, Appendix A.

* * * * *

PART 57—SAFETY AND HEALTH STANDARDS—UNDERGROUND METAL AND NONMETAL MINES

■ 3. The authority citation for part 57 continues to read as follows:

Authority: 30 U.S.C. 811.

■ 4. Section 57.5001 is amended by revising paragraph (b) to read as follows:

§ 57.5001 Exposure limits for airborne contaminants.

* * * * *

(b) *Asbestos standard*—(1) *Definitions.* Asbestos is a generic term

for a number of hydrated silicates that, when crushed or processed, separate into flexible fibers made up of fibrils. As used in this part—

Asbestos means chrysotile, cummingtonite-grunerite asbestos (amosite), crocidolite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos.

Fiber means a particle longer than 5 micrometers (µm) with a length-to-diameter ratio of at least 3-to-1.

(2) *Permissible Exposure Limits (PELs)*—(i) *Full-shift limit*. A miner's personal exposure to asbestos shall not exceed an 8-hour time-weighted average full-shift airborne concentration of 0.1 fiber per cubic centimeter of air (f/cc).

(ii) *Excursion limit*. No miner shall be exposed at any time to airborne concentrations of asbestos in excess of 1 fiber per cubic centimeter of air (f/cc) as averaged over a sampling period of 30 minutes.

(3) *Measurement of airborne fiber concentration*. Fiber concentration shall be determined by phase contrast microscopy using a method statistically equivalent to the OSHA Reference Method in OSHA's asbestos standard found in 29 CFR 1910.1001, Appendix A.

* * * * *

PART 71—MANDATORY HEALTH STANDARDS—SURFACE COAL MINES AND SURFACE WORK AREAS OF UNDERGROUND COAL MINES

■ 5. The authority citation for part 71 continues to read as follows:

Authority: 30 U.S.C. 811, 951, 957.

■ 6. Section 71.701 is amended by revising paragraphs (c) and (d) to read as follows:

§ 71.701 Sampling; general requirements.

* * * * *

(c) Where concentrations of airborne contaminants in excess of the applicable threshold limit values, permissible exposure limits, or permissible excursions are known by the operator to exist in a surface installation or at a surface worksite, the operator shall immediately provide necessary control measures to assure compliance with § 71.700 or § 71.702, as applicable.

(d) Where the operator has reasonable grounds to believe that concentrations of airborne contaminants in excess of the applicable threshold limit values, permissible exposure limits, or permissible excursions exist, or are likely to exist, the operator shall promptly conduct appropriate air sampling tests to determine the concentration of any airborne contaminant which may be present and immediately provide the necessary control measures to assure compliance with § 71.700 or § 71.702, as applicable.

■ 7. Section 71.702 is revised to read as follows:

§ 71.702 Asbestos standard.

(a) *Definitions*. Asbestos is a generic term for a number of hydrated silicates that, when crushed or processed, separate into flexible fibers made up of fibrils. As used in this part—

Asbestos means chrysotile, cummingtonite-grunerite asbestos (amosite), crocidolite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos.

Fiber means a particle longer than 5 micrometers (µm) with a length-to-diameter ratio of at least 3-to-1.

(b) *Permissible Exposure Limits (PELs)*— (1) *Full-shift limit*. A miner's personal exposure to asbestos shall not exceed an 8-hour time-weighted average full-shift airborne concentration of 0.1 fiber per cubic centimeter of air (f/cc).

(2) *Excursion limit*. No miner shall be exposed at any time to airborne concentrations of asbestos in excess of 1 fiber per cubic centimeter of air (f/cc) as averaged over a sampling period of 30 minutes.

(c) *Measurement of airborne fiber concentration*. Fiber concentration shall be determined by phase contrast microscopy using a method statistically equivalent to the OSHA Reference Method in OSHA's asbestos standard found in 29 CFR 1910.1001, Appendix A.

[FR Doc. E8-3828 Filed 2-28-08; 8:45 am]

BILLING CODE 4510-43-P

Exhibit 94

Johnson & Johnson

EXHIBIT I

June 28, 1977

SUBJECT: Audit Testing of Windsor 66 Talc for Asbestos

TO: Mr. G. Lee

FROM: Mr. A. Frank

To formalize the audit testing currently performed to ensure the absence of asbestos in Windsor 66 Talc, the following protocol is currently being used:

1) Scope

Windsor 66 talc is manufactured from a previously approved mine site known to contain an acceptable cosmetic grade talc ore which has been tested by and has met the requirements for detectable asbestos by the test methods and sampling plan described below. Windsor Minerals will assure mine site evaluation data to include analysis of diamond drill core samples, and deposit testing of composite ore samples removed from the mine site during the development phase prior to production of cosmetic talc to be used for JOHNSON'S* Baby Powder.

Asbestos is defined to be the fibrous serpentine, chrysotile and the fibrous forms of the amphibole group as represented by amosite, anthophyllite, crocidolite, tremolite asbestos and actinolite.

2) Testing Requirements

<u>CHARACTERISTIC</u>	<u>TEST METHOD</u>	<u>REQUIREMENT</u>
Fibrous Amphibole Forms	CTFA J4-1	None detected
Serpentine Forms (Chrysotile)	TM 7019	None detected
Asbestiform Minerals (fibrous forms) (Transmission Electron Microscopy)	TM 7024	None detected

-continued-

PLAINTIFF'S
EXHIBIT
JNJ-56

3) Testing Procedure/Frequency

The following sample types are tested on an audit basis according to the test procedures and frequencies noted.

<u>SAMPLE TYPE</u>	<u>TESTS</u>	<u>FREQUENCY</u>
Raymond Grind	TM 7024	bi-weekly composite sample
Flash Dried Talc	CTFA J4-1 TM 7019	weekly composite samples
Finished Talc	TM 7024	quarterly audit of random sample

A. M. Frank

A. M. Frank

AMF:eap

cc: H. Cohen
L. Orlando
J. Runnells



J&J Consumer Companies Worldwide Specification

Issued

Strictly Confidential

ANALYSIS OF POWDERED TALC FOR ASBESTIFORM MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

Name
TM7024

Type
Test Method

Revision	1	Owner	Corporate
Issued Date	1995-08-21	Expiration Date	9999-12-31
Geographical Scope	Local	Specification Category	Permanent
Security Classification		Review Interval (Months)	0

Related Information

Template	Test Method Global	SCO
Co-Owners		Owning Region
		North America

Revisions

Name	Rev	State	Description of Change	Reason for Change	Owner	Issued Date	Expiration Date
TM7024	1	Issued			Corporate	1995-08-21	9999-12-31

Approvals

Signer	Role	Organizations	Date/Time
No Objects Found			

Content

Name	Format	File Size
TM7024.doc	generic	35840

Reference Documents

Name	Description

PLAINTIFF'S
EXHIBIT
JNJ-54

No Objects Found

Related Specifications

Name	Type
No Objects Found	

User Defined Attributes

No Objects Found

Additional Attributes

No Objects Found

ISSUED

Test Method

Company:

☐ *Personal Products Worldwide*
☐ *Personal Products Company*
☐ *Desbiens Products Inc.*

☐ *Johnson & Johnson Products Inc.*
☐ *Odonto Corporation Ltd.*
☒ *Johnson & Johnson Consumer Products Co.*

Document No.: TM7024

Franchise:

Location: ROYSTON, FLUID, KOLMAR

Document Type: Permanent

Expiration Date: None

Subject: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM MINERALS BY TRANSMISSION ELECTRON
MICROSCOPY

<u>REVISION</u>	<u>AUTHORIZATION</u>	<u>DESCRIPTION OF CHANGE</u>
03/08/89	BCR011362	New Test method.
03/21/95	CR020127	Location revised. (Spec. Dept.)
08/21/95	CR020688	Location revised. (Spec. Dept.)

ISSUED

Test Method

Company:

☐ *Personal Products Worldwide*
☐ *Personal Products Company*
☐ *Desbiens Products Inc.*

☐ *Johnson & Johnson Products Inc.*
☐ *Odonto Corporation Ltd.*
☒ *Johnson & Johnson Consumer Products Co.*

Document No.: TM7024

Franchise:

Location: ROYSTON, FLUID, KOLMAR

Document Type: Permanent

Expiration Date: None

Subject: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

1.0 SCOPE & PURPOSE

This method is applicable to the identification and quantitation of small (typically 1-20 micrometer) asbestiform minerals in powdered talc. Samples may be previously screened with light microscopy or x-ray diffraction techniques.

2.0 PRINCIPLE OF METHOD

The combined techniques of transmission electron microscopy (TEM), selected area electron diffraction (SAED) and energy dispersive x-ray analysis (EDXRA) permit the detection of asbestiform minerals based on morphological characteristics, followed by a definitive mineralogical identification of each fiber.

3.0 INTERFERENCES

Interferences are caused by fibrous particles which must be distinguished from positively identifiable asbestos, and by large particles or particle aggregates which may obscure fibers. Positively identified non-asbestos fibers include rolled talc, ribbon talc, antigorite, silica fibers and iron oxide fibers. Organic additives such as perfumes may crystallize out as fibers or needle-shaped crystals in finished cosmetic products. In the absence of positive identification, all other fibers must be classified as unidentifiable.

4.0 INSTRUMENTAL CONDITIONS

The talc specimen grids are examined in the TEM at an accelerating voltage of 120 kv and at magnification of 20,000X and 5,000X.

5.0 SENSITIVITY

This method is capable of detecting a single fiber as small as 1 micrometer (mm) long by 0.075 mm wide in the entire TEM field, which results in a theoretical detection limit of 10^{-5} weight percent. Such fibers usually can be identified readily by SAED and EDXRA. The mass of a fiber with the above dimensions is 1.1×10^{-14} g for chrysotile and 1.5×10^{-14} g for amphibole.

6.0 LIMIT OF QUANTIFIABLE DETECTION

The detection of five or more asbestiform minerals of one variety in an analysis constitutes a quantifiable level of detection. When no asbestiform minerals are detected, a representative fiber size is used to calculate a detection limit. A representative fiber size is 3 mm long by 0.2 mm wide by 0.06 mm thick, which is considerably larger than the smallest fiber that can be detected (see section 5, SENSITIVITY), but is more typical of small asbestos fibers that are detected in talc analyses. The mass of five such fibers is calculated as follows:

$$\begin{aligned} 3 \text{ mm} \times 0.2 \text{ mm} \times 0.06 \text{ mm} &= 0.036 \text{ mm}^3 \text{ per fiber} \\ \times 3.3\text{E-}12 \text{ g / mm}^3 &= 1.2 \text{ E-}13 \text{ g per fiber} \end{aligned}$$

Test Method

Company:

☐ *Personal Products Worldwide*
☐ *Personal Products Company*
☐ *Desbiens Products Inc.*

☐ *Johnson & Johnson Products Inc.*
☐ *Odonto Corporation Ltd.*
☒ *Johnson & Johnson Consumer Products Co.*

Document No.: TM7024

Franchise:

Location: ROYSTON, FLUID, KOLMAR

Document Type: Permanent

Expiration Date: None

Subject: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

x 5 fibers = 6E-13 grams per 5 fibers.

The limit of quantifiable detection for most talc analyses is approximately 6×10^{-4} weight percent. The theoretical and quantifiable detection limits assume homogeneity of the material being sampled.

7.0 QUALITY ASSURANCE

Blank suspensions are routinely prepared and tested in order to monitor potential residual contamination from the sample jars. Blank carbon-coated grids are routinely tested to monitor the ambient fiber count. If greater than 4 fibers per grid are present, the jars are pre-cleaned or new carbon-coated grids are prepared, respective of the test.

8.0 BACKGROUND CORRECTION

As of the time of this writing, background correction has not been necessary. The amount of background asbestos detected has been insignificant in comparison to the levels of asbestos found in contaminated samples.

9.0 PREPARATION AND ANALYSIS TIME

Preparation time per sample (including preparation of related materials) is one hour. Analysis search time per sample is a maximum of two hours.

10.0 APPARATUS

- 10.1 Analytical balance with 0.0001 gram sensitivity
- 10.2 Weighing boats
- 10.3 Narrow spatula
- 10.4 Wide mouth polyethylene jars (125 ml)
- 10.5 Mild ultrasonic bath, minimum 50 watts
- 10.6 Micropipettor (5-10 ml range) with disposable tips
- 10.7 Standard 3 mm diameter, 200 mesh, copper TEM grids, covered with a carbon-coated formvar film.
- 10.8 Transmission electron microscope (TEM) with an 80-120 kv accelerating voltage and energy dispersive x-ray analyzer.

Test Method

Company:

☐ *Personal Products Worldwide*
☐ *Personal Products Company*
☐ *Desbiens Products Inc.*

☐ *Johnson & Johnson Products Inc.*
☐ *Odonto Corporation Ltd.*
☒ *Johnson & Johnson Consumer Products Co.*

Document No.: TM7024

Franchise:

Location: ROYSTON, FLUID, KOLMAR

Document Type: Permanent

Expiration Date: None

Subject: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

11.0 REAGENTS

11.1 Methyl cellulose, powder, USP 4000 cps - Fisher Certified Reagent #M-352 or equivalent

11.2 Water: deionized, particle free (+0.2 mm filtered)

11.3 Methyl cellulose solution: 0.002% (wt/vl) (20 ppm). Dissolve 20 % 0.5 mg of methyl cellulose in 500 ml of deionized particle free water to make a 0.004% stock solution. Dilute 1:1 to make a working solution.

NOTE: Methyl cellulose acts as a wetting agent to aid in maintaining a uniform particle distribution as the sample dries, by greatly reducing the surface tension of water.

12.0 SAMPLE PREPARATION

12.1 Transfer 30 to 50 mg of talc powder to a clean 125 ml polyethylene jar.

12.2 Add 80 ml of 20 ppm methyl cellulose solution, cap and shake vigorously for one minute.

12.3 After shaking, loosen cap and ultrasonicate for 10 minutes in order to disperse the finer particles. Then shake again for one minute to produce a uniform suspension.

12.4 Immediately after shaking, uncap and remove 9.2 microliters with a micropipette.

12.5 Transfer a 9 ml drop to a carbon film covered TEM grid. (Grid was first lightly anchored by 2 parallel strips of double-stick tape mounted 3 mm apart on a clean glass microscope slide.) Repeat to make two sample grids per talc sample.

NOTE: Do not expel the remaining 0.2 ml suspension from the micropipette tip. It tends to sputter and frequently destroys the stability of the sample drop.

12.6 Transfer slide with grids to a desiccator. (Drying time is 2-3 hours.) Do not leave the grids on the slide for more than one day as the double-stick tape may adhere too tightly.

NOTE: The talc:water ratio may need to be varied for some samples. Preparation of talc samples with a significantly finer or coarser particle size results in large differences in particle coverage on the TEM grid.

Test Method

Company:

☐ *Personal Products Worldwide*
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Document No.: TM7024

Franchise:

Location: ROYSTON, FLUID, KOLMAR

Document Type: Permanent

Expiration Date: None

Subject: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

13.0 TEM ANALYSIS

- 13.1 Definition of fiber: An elongated particle with parallel sides and an aspect ratio K3:1. The definition employed may vary with the needs of the client.
- 13.2 Scan sample at 120-150X magnification to check for even dispersion of particles and to locate grid squares with optimum particle density. (Optimum particle density is particle coverage over 15-35% of the field of view.)
- 13.3 Scan three grid squares on each grid at 20,000X magnification and seven grid squares on each grid at 5,000X for asbestiform minerals. Each asbestiform mineral is recorded as to type (chrysotile, tremolite, anthophyllite, etc.), structure (bundle, clump, fiber) and dimensions (length x width).
- 13.4 Questionable fibers are examined first by SAED. The chrysotile SAED pattern is unique and diagnostic. Amphibole SAED patterns are variable but usually characteristic. Additional analysis and measurement of amphibole SAED patterns are done if warranted.
- 13.5 Ten percent of chrysotile fibers are checked by EDXRA for further confirmation. If the SAED pattern is not clearly diagnostic, or if it is consistent with an amphibole SAED pattern, then it is examined by EDXRA to confirm the identification or to identify the type of amphibole.

14.0 CALCULATION OF RESULTS

- 14.1 Mass of chrysotile fibers: $M(f)$
 $M(f) = \pi r^2 l \times d$
 $\pi = 3.14159$
 r = fiber radius
 l = fiber length
 d = density of chrysotile = 2.55×10^{-12} g/mm³
- 14.2 Mass of asbestiform amphibole particles: $M(a)$
 $M(a) = l \times w \times th \times d$
 l = length
 w = width
 th = thickness Z 0.3 width (approximation)
 d = density of amphiboles = 3.3×10^{-13} g/mm³
- 14.3 Mass of talc deposited on each TEM grid: $M(s)$
 $M(s) = T \times (V/H)$
 T = amount of talc sampled (step 12.1)
 V = volume of aliquot transferred to TEM grid (step 12.5)

Test Method

Company:

☐ *Personal Products Worldwide*
☐ *Personal Products Company*
☐ *Desbiens Products Inc.*

☐ *Johnson & Johnson Products Inc.*
☐ *Odonto Corporation Ltd.*
☒ *Johnson & Johnson Consumer Products Co.*

Document No.: TM7024

Franchise:

Location: ROYSTON, FLUID, KOLMAR

Document Type: Permanent

Expiration Date: None

Subject: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

H = volume of methyl cellulose solution (step 12.2)

14.4 Total estimated talc mass examined: $M(t)$

$M(t) = M(s) \times (N \times A(s))/A(g)$

N = number of grid squares examined

A(s) = area of a single TEM grid square

A(g) = area of an entire TEM grid (effective area over which a 9 microliter drop of suspension dries)

14.5 Weight percent:

$$\frac{\text{sum total of } M(f) \text{ or } M(a) \times 100}{M(t)}$$

15.0 CALCULATION OF A DETECTION LIMIT

15.1 $M(dl)$ = A minimum quantifiable mass of asbestos fibers, based on the detection of 5 fibers (approximately $6E-13$ grams, from Section 6).

15.2 Detection Limit (Weight Percent) = $\frac{M(dl) \times 100}{M(t)}$

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END OF DOCUMENT

ISSUED

Exhibit 95

SPEC NO: TM7024

DOC TYPE:Test Method

SUBJECT:Analysis of Powdered Talc for Asbestiform Minerals by Transmission Electron
Microscopy

LOCATION:

REVISION	AUTHORIZATION	DESCRIPTION OF CHANGE
03/08/89	BCR011362	Test method updated.

PLAINTIFF'S
EXHIBIT
JNJ-1142

SPEC NO: TM7024

DOC TYPE:Test Method

SUBJECT:Analysis of Powdered Talc for Asbestiform Minerals by Transmission
Electron Microscopy

LOCATION:

PRODUCT(S):

SPEC NO: TM7024

DOC TYPE: Test Method

SUBJECT: Analysis of Powdered Talc for Asbestiform Minerals by Transmission Electron Microscopy

LOCATION:

1. SCOPE & PURPOSE

This method is applicable to the identification and quantitation of small (typically 1-20 micrometer) asbestiform minerals in powdered talc. Samples may be previously screened with light microscopy or x-ray diffraction techniques.

2. PRINCIPLE OF METHOD

The combined techniques of transmission electron microscopy (TEM), selected area electron diffraction (SAED) and energy dispersive x-ray analysis (EDXRA) permit the detection of asbestiform minerals based on morphological characteristics, followed by a definitive mineralogical identification of each fiber.

3. INTERFERENCES

Interferences are caused by fibrous particles which must be distinguished from positively identifiable asbestos, and by large particles or particle aggregates which may obscure fibers. Positively identified non-asbestos fibers include rolled talc, ribbon talc, antigorite, silica fibers and iron oxide fibers. Organic additives such as perfumes may crystallize out as fibers or needle-shaped crystals in finished cosmetic products. In the absence of positive identification, all other fibers must be classified as unidentifiable.

4. INSTRUMENTAL CONDITIONS

The talc specimen grids are examined in the TEM at an accelerating voltage of 120 kv and at magnification of 20,000X and 5,000X.

5. SENSITIVITY

This method is capable of detecting a single fiber as small as 1 micrometer (mm) long by 0.075 mm wide in the entire TEM field, which results in a theoretical detection limit of 10^{-5} weight percent. Such fibers usually can be identified readily by SAED and EDXRA. The mass of a fiber with the above dimensions is 1.1×10^{-14} g for chrysotile and 1.5×10^{-14} g for amphibole.

6. LIMIT OF QUANTIFIABLE DETECTION

The detection of five or more asbestiform minerals of one variety in an analysis constitutes a quantifiable level of detection. When no asbestiform minerals are detected, a representative fiber size is used to calculate a detection limit. A representative fiber size is 3 mm long by 0.2 mm wide by 0.06 mm thick, which is considerably larger than the smallest fiber that can be detected (see section 5, SENSITIVITY), but is more typical of small asbestos fibers that are detected in talc analyses. The mass of five such fibers is calculated as follows:

$$\begin{aligned} 3 \text{ mm} \times 0.2 \text{ mm} \times 0.06 \text{ mm} &= 0.036 \text{ mm}^3 \text{ per fiber} \\ \times 3.3\text{E-}12 \text{ g / mm}^3 &= 1.2 \text{ E-}13 \text{ g per fiber} \\ \times 5 \text{ fibers} &= 6\text{E-}13 \text{ grams per 5 fibers.} \end{aligned}$$

The limit of quantifiable detection for most talc analyses is approximately 6×10^{-4} weight percent. The theoretical and quantifiable detection limits assume homogeneity of the material being sampled.

7. QUALITY ASSURANCE

Blank suspensions are routinely prepared and tested in order to monitor potential residual contamination from the sample jars. Blank carbon-coated grids are routinely tested to monitor the ambient fiber count. If greater than 4 fibers per grid are present, the jars are pre-cleaned or new carbon-coated grids are prepared, respective of the test.

8. BACKGROUND CORRECTION

SPEC NO: TM7024

DOC TYPE: Test Method

SUBJECT: Analysis of Powdered Talc for Asbestiform Minerals by Transmission Electron Microscopy

LOCATION:

As of the time of this writing, background correction has not been necessary. The amount of background asbestos detected has been insignificant in comparison to the levels of asbestos found in contaminated samples.

9. PREPARATION AND ANALYSIS TIME

Preparation time per sample (including preparation of related materials) is one hour. Analysis search time per sample is a maximum of two hours.

10. APPARATUS

A. Analytical balance with 0.0001 gram sensitivity

B. Weighing boats

C. Narrow spatula

D. Wide mouth polyethylene jars (125 ml)

E. Mild ultrasonic bath, minimum 50 watts

F. Micropipettor (5-10 ml range) with disposable tips

G. Standard 3 mm diameter, 200 mesh, copper TEM grids, covered with a carbon-coated formvar film.

H. Transmission electron microscope (TEM) with an 80-120 kv accelerating voltage and energy dispersive x-ray analyzer.

11. REAGENTS

A. Methyl cellulose, powder, USP 4000 cps - Fisher Certified Reagent #M-352 or equivalent

B. Water: deionized, particle free (+0.2 mm filtered)

C. Methyl cellulose solution: 0.002% (wt/vl) (20 ppm). Dissolve 20 % 0.5 mg of methyl cellulose in 500 ml of deionized particle free water to make a 0.004% stock solution. Dilute 1:1 to make a working solution.

NOTE: Methyl cellulose acts as a wetting agent to aid in maintaining a uniform particle distribution as the sample dries, by greatly reducing the surface tension of water.

12. SAMPLE PREPARATION

12.1. Transfer 30 to 50 mg of talc powder to a clean 125 ml polyethylene jar.

12.2. Add 80 ml of 20 ppm methyl cellulose solution, cap and shake vigorously for one minute.

12.3. After shaking, loosen cap and ultrasonicate for 10 minutes in order to disperse the finer particles. Then shake again for one minute to produce a uniform suspension.

12.4. Immediately after shaking, uncap and remove 9.2 microliters with a micropipette.

12.5. Transfer a 9 ml drop to a carbon film covered TEM grid. (Grid was first lightly anchored by 2 parallel strips of double-stick tape mounted 3 mm apart on a clean glass microscope slide.) Repeat to make two sample grids per talc sample.

NOTE: Do not expel the remaining 0.2 ml suspension from the micropipette tip. It tends to sputter and frequently destroys the stability of the sample drop.

SPEC NO: TM7024

DOC TYPE: Test Method

SUBJECT: Analysis of Powdered Talc for Asbestiform Minerals by Transmission
Electron Microscopy

LOCATION:

12.6 Transfer slide with grids to a desiccator. (Drying time is 2-3 hours.) Do not leave the grids on the slide for more than one day as the double-stick tape may adhere too tightly.

NOTE: The talc:water ratio may need to be varied for some samples. Preparation of talc samples with a significantly finer or coarser particle size results in large differences in particle coverage on the TEM grid.

13. TEM ANALYSIS

13.1 Definition of fiber: An elongated particle with parallel sides and an aspect ratio $\geq 3:1$. The definition employed may vary with the needs of the client.

13.2 Scan sample at 120-150X magnification to check for even dispersion of particles and to locate grid squares with optimum particle density. (Optimum particle density is particle coverage over 15-35% of the field of view.)

13.3 Scan three grid squares on each grid at 20,000X magnification and seven grid squares on each grid at 5,000X for asbestiform minerals. Each asbestiform mineral is recorded as to type (chrysotile, tremolite, anthophyllite, etc.), structure (bundle, clump, fiber) and dimensions (length x width).

13.4 Questionable fibers are examined first by SAED. The chrysotile SAED pattern is unique and diagnostic. Amphibole SAED patterns are variable but usually characteristic. Additional analysis and measurement of amphibole SAED patterns are done if warranted.

13.5 Ten percent of chrysotile fibers are checked by EDXRA for further confirmation. If the SAED pattern is not clearly diagnostic, or if it is consistent with an amphibole SAED pattern, then it is examined by EDXRA to confirm the identification or to identify the type of amphibole.

14. CALCULATION OF RESULTS

14.1.A. Mass of chrysotile fibers: $M(f)$

$$M(f) = \pi r^2 l \times d$$

$\pi = 3.14159$
 r = fiber radius
 l = fiber length
 d = density of chrysotile = $2.55 \times 10^{-12} \text{ g/mm}^3$

14.1.B. Mass of asbestiform amphibole particles: $M(a)$

$$M(a) = l \times w \times th \times d$$

l = length
 w = width
 th = thickness ≥ 0.3 width (approximation)
 d = density of amphiboles = $3.3 \times 10^{-13} \text{ g/mm}^3$

14.2.A. Mass of talc deposited on each TEM grid: $M(s)$

$$M(s) = T \times (V/H)$$

T = amount of talc sampled (step 12.1)
 V = volume of aliquot transferred to TEM grid (step 12.5)
 H = volume of methyl cellulose solution (step 12.2)

14.2.B. Total estimated talc mass examined: $M(t)$

$$M(t) = M(s) \times (N \times A(s))/A(g)$$

N = number of grid squares examined
 $A(s)$ = area of a single TEM grid square
 $A(g)$ = area of an entire TEM grid (effective area over which a 9 microliter

SPEC NO: TM7024

DOC TYPE:Test Method

SUBJECT:Analysis of Powdered Talc for Asbestiform Minerals by Transmission
Electron Microscopy

LOCATION:

. drop of suspension dries)

14.3. Weight percent:

$$\frac{\text{sum total of } M(f) \text{ or } M(a) \times 100}{M(t)}$$

15. CALCULATION OF A DETECTION LIMIT

15.1.M(dl) =A minimum quantifiable mass of asbestos fibers, based on the detection of 5 fibers
(approximately 6E-13 grams, from Section 6).

15.2. Detection Limit (Weight Percent) = $\frac{M(dl) \times 100}{M(t)}$

Exhibit 96

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Page 1 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

REVISION	AUTHORIZATION	DESCRIPTION OF CHANGE
03/08/89	BCR011362	New Test method.
03/21/95	CR020127	Location revised. (Spec. Dept.)



JOHNSON & JOHNSON
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Page 2 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

1.0 SCOPE & PURPOSE

This method is applicable to the identification and quantitation of small (typically 1-20 micrometer) asbestiform minerals in powdered talc. Samples may be previously screened with light microscopy or x-ray diffraction techniques.

2.0 PRINCIPLE OF METHOD

The combined techniques of transmission electron microscopy (TEM), selected area electron diffraction (SAED) and energy dispersive x-ray analysis (EDXRA) permit the detection of asbestiform minerals based on morphological characteristics, followed by a definitive mineralogical identification of each fiber.

3.0 INTERFERENCES

Interferences are caused by fibrous particles which must be distinguished from positively identifiable asbestos, and by large particles or particle aggregates which may obscure fibers. Positively identified non-asbestos fibers include rolled talc, ribbon talc, antigorite, silica fibers and iron oxide fibers. Organic additives such as perfumes may crystallize out as fibers or needle-shaped crystals in finished cosmetic products. In the absence of positive identification, all other fibers must be classified as unidentifiable.

4.0 INSTRUMENTAL CONDITIONS

The talc specimen grids are examined in the TEM at an accelerating voltage of 120 kv and at magnification of 20,000X and 5,000X.

5.0 SENSITIVITY

This method is capable of detecting a single fiber as small as 1 micrometer (mm) long by 0.075 mm wide in the entire TEM field, which results in a theoretical detection limit of 10^{-5} weight percent. Such fibers usually can be identified readily by SAED and EDXRA. The mass of a fiber

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Page 3 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

with the above dimensions is 1.1×10^{-14} g for chrysotile
and 1.5×10^{-14} g for amphibole.

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Page 4 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

6.0 LIMIT OF QUANTIFIABLE DETECTION

The detection of five or more asbestiform minerals of one variety in an analysis constitutes a quantifiable level of detection. When no asbestiform minerals are detected, a representative fiber size is used to calculate a detection limit. A representative fiber size is 3 mm long by 0.2 mm wide by 0.06 mm thick, which is considerably larger than the smallest fiber that can be detected (see section 5, SENSITIVITY), but is more typical of small asbestos fibers that are detected in talc analyses. The mass of five such fibers is calculated as follows:

$$\begin{aligned} 3 \text{ mm} \times 0.2 \text{ mm} \times 0.06 \text{ mm} &= 0.036 \text{ mm}^3 \text{ per fiber} \\ \times 3.3\text{E-}12 \text{ g / mm}^3 &= 1.2 \text{ E-}13 \text{ g per fiber} \\ \times 5 \text{ fibers} &= 6\text{E-}13 \text{ grams per 5 fibers.} \end{aligned}$$

The limit of quantifiable detection for most talc analyses is approximately 6×10^{-4} weight percent. The theoretical and quantifiable detection limits assume homogeneity of the material being sampled.

7.0 QUALITY ASSURANCE

Blank suspensions are routinely prepared and tested in order to monitor potential residual contamination from the sample jars. Blank carbon-coated grids are routinely tested to monitor the ambient fiber count. If greater than 4 fibers per grid are present, the jars are pre-cleaned or new carbon-coated grids are prepared, respective of the test.

8.0 BACKGROUND CORRECTION

As of the time of this writing, background correction has not been necessary. The amount of background asbestos detected has been insignificant in comparison to the levels of asbestos found in contaminated samples.

9.0 PREPARATION AND ANALYSIS TIME

Preparation time per sample (including preparation of related materials) is one hour. Analysis search time per

JOHNSON & JOHNSON
CONSUMER PRODUCTS, INC.

Page 5 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

sample is a maximum of two hours.

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Page 6 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

10.0 APPARATUS

- 10.1 Analytical balance with 0.0001 gram sensitivity
- 10.2 Weighing boats
- 10.3 Narrow spatula
- 10.4 Wide mouth polyethylene jars (125 ml)
- 10.5 Mild ultrasonic bath, minimum 50 watts
- 10.6 Micropipettor (5-10 ml range) with disposable tips
- 10.7 Standard 3 mm diameter, 200 mesh, copper TEM grids, covered with a carbon-coated formvar film.
- 10.8 Transmission electron microscope (TEM) with an 80-120 kv accelerating voltage and energy dispersive x-ray analyzer.

11.0 REAGENTS

- 11.1 Methyl cellulose, powder, USP 4000 cps - Fisher Certified Reagent #M-352 or equivalent
- 11.2 Water: deionized, particle free (+0.2 mm filtered)
- 11.3 Methyl cellulose solution: 0.002% (wt/vl) (20 ppm). Dissolve 20 % 0.5 mg of methyl cellulose in 500 ml of deionized particle free water to make a 0.004% stock solution. Dilute 1:1 to make a working solution.

NOTE: Methyl cellulose acts as a wetting agent to aid in maintaining a uniform particle distribution as the sample dries, by greatly reducing the surface tension of water.

12.0 SAMPLE PREPARATION

- 12.1 Transfer 30 to 50 mg of talc powder to a clean 125 ml polyethylene jar.

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Page 7 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

12.2 Add 80 ml of 20 ppm methyl cellulose solution, cap and
shake vigorously for one minute.

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Page 8 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

12.3 After shaking, loosen cap and ultrasonicate for 10 minutes in order to disperse the finer particles. Then shake again for one minute to produce a uniform suspension.

12.4 Immediately after shaking, uncap and remove 9.2 microliters with a micropipette.

12.5 Transfer a 9 ml drop to a carbon film covered TEM grid. (Grid was first lightly anchored by 2 parallel strips of double-stick tape mounted 3 mm apart on a clean glass microscope slide.) Repeat to make two sample grids per talc sample.

NOTE: Do not expel the remaining 0.2 ml suspension from the micropipette tip. It tends to sputter and frequently destroys the stability of the sample drop.

12.6 Transfer slide with grids to a desiccator. (Drying time is 2-3 hours.) Do not leave the grids on the slide for more than one day as the double-stick tape may adhere too tightly.

NOTE: The talc:water ratio may need to be varied for some samples. Preparation of talc samples with a significantly finer or coarser particle size results in large differences in particle coverage on the TEM grid.

13.0 TEM ANALYSIS

13.1 Definition of fiber: An elongated particle with parallel sides and an aspect ratio $K3:1$. The definition employed may vary with the needs of the client.

13.2 Scan sample at 120-150X magnification to check for even dispersion of particles and to locate grid squares with optimum particle density. (Optimum particle density is particle coverage over 15-35% of the field of view.)

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Page 9 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

13.3 Scan three grid squares on each grid at 20,000X magnification and seven grid squares on each grid at 5,000X for asbestiform minerals. Each asbestiform mineral is recorded as to type (chrysotile, tremolite, anthophyllite, etc.), structure (bundle, clump, fiber) and dimensions (length x width).

13.4 Questionable fibers are examined first by SAED. The chrysotile SAED pattern is unique and diagnostic. Amphibole SAED patterns are variable but usually characteristic. Additional analysis and measurement of amphibole SAED patterns are done if warranted.

13.5 Ten percent of chrysotile fibers are checked by EDXRA for further confirmation. If the SAED pattern is not clearly diagnostic, or if it is consistent with an amphibole SAED pattern, then it is examined by EDXRA to confirm the identification or to identify the type of amphibole.

14.0 CALCULATION OF RESULTS

14.1 Mass of chrysotile fibers: $M(f)$

$$M(f) = \pi r^2 l \times d$$

$$\pi = 3.14159$$

r = fiber radius

l = fiber length

$$d = \text{density of chrysotile} = 2.55 \times 10^{-12} \text{ g/mm}^3$$

14.2 Mass of asbestiform amphibole particles: $M(a)$

$$M(a) = l \times w \times th \times d$$

l = length

w = width

th = thickness ≤ 0.3 width (approximation)

$$d = \text{density of amphiboles} = 3.3 \times 10^{-13} \text{ g/mm}^3$$

14.3 Mass of talc deposited on each TEM grid: $M(s)$

$$M(s) = T \times (V/H)$$

T = amount of talc sampled (step 12.1)

V = volume of aliquot transferred to TEM grid (step 12.5)

H = volume of methyl cellulose solution (step 12.2)

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Page 10 of 7
SPEC NO: TM7024
REV: 03/21/95

DOC TYPE: TEST METHOD SPECIFICATION

SUBJECT: ANALYSIS OF POWDERED TALC FOR ASBESTIFORM
MINERALS BY TRANSMISSION ELECTRON MICROSCOPY

LOCATION: ROYSTON

14.4 Total estimated talc mass examined: $M(t)$

$$M(t) = M(s) \times (N \times A(s)) / A(g)$$

N = number of grid squares examined

A(s) = area of a single TEM grid square

A(g) = area of an entire TEM grid (effective area
over which a 9 microliter drop of
suspension dries)

14.5 Weight percent:

$$\frac{\text{sum total of } M(f) \text{ or } M(a) \times 100}{M(t)}$$

15.0 CALCULATION OF A DETECTION LIMIT

15.1 $M(dl)$ = A minimum quantifiable mass of asbestos
fibers, based on the detection of 5 fibers
(approximately $6E-13$ grams, from Section 6).

$$15.2 \text{ Detection Limit (Weight Percent)} = \frac{M(dl) \times 100}{M(t)}$$

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INTERNATIONAL STANDARD

ISO
22262-1

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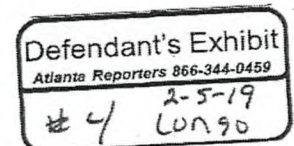
Air quality — Bulk materials —

Part 1:

Sampling and qualitative determination of asbestos in commercial bulk materials

Qualité de l'air — Matériaux solides —

*Partie 1: Échantillonnage et dosage qualitatif de l'amiante dans les
matériaux solides d'origine commerciale*



Reference number
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Case postale 56 • CH-1211 Geneva 20
Tel + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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Contents	Page
Foreword	v
Introduction	vi
1 Scope	1
2 Terms and definitions	1
3 Symbols and abbreviated terms	7
4 Principle	8
4.1 General	8
4.2 Substance determination	8
4.3 Type of sample	8
4.4 Range	8
4.5 Limit of detection	9
4.6 Limitations of PLM in the detection of asbestos	9
5 Sample collection	9
5.1 Requirements	9
5.2 Procedure	10
6 Sample preparation	14
6.1 General	14
6.2 Removal of organic materials by ashing	14
6.3 Removal of soluble constituents by acid treatment	14
6.4 Sedimentation and flotation	14
6.5 Combination of gravimetric reduction procedures	14
7 Analysis by PLM	14
7.1 Requirements	14
7.2 Qualitative analysis by PLM	19
8 Analysis by SEM	29
8.1 General	29
8.2 Requirements	29
8.3 Calibration	29
8.4 Sample preparation	30
8.5 Qualitative analysis by SEM	30
9 Analysis by transmission electron microscope	31
9.1 General	31
9.2 Requirements	32
9.3 Calibration	32
9.4 Sample preparation	33
9.5 Qualitative analysis by TEM	33
10 Test report	35
Annex A (normative) Types of commercial asbestos-containing material	36
Annex B (normative) Interference colour chart	40
Annex C (normative) Dispersion staining charts	41
Annex D (normative) Asbestos identification by PLM and dispersion staining in commercial materials	43
Annex E (normative) Asbestos identification by SEM in commercial materials	52
Annex F (normative) Asbestos identification by TEM in commercial materials	58
Annex G (informative) Example of sampling record	67
Annex H (informative) Example of test report	68

ISO 22262-1:2012(E)

Bibliography 69

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 22262-1 was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 3, *Ambient atmospheres*.

ISO 22262 consists of the following parts, under the general title *Air quality — Bulk materials*:

- *Part 1: Sampling and qualitative determination of asbestos in commercial bulk materials*

The following part is under preparation:

- *Part 2: Quantitative determination of asbestos by gravimetric and microscopical methods*

ISO 22262-1:2012(E)

Introduction

In the past, asbestos was used in a wide range of products. Three varieties of asbestos found extensive commercial application. Chrysotile accounted for approximately 95 % of consumption, and this variety is therefore likely to be encountered most frequently during the analysis of samples. Materials containing high proportions of chrysotile asbestos were used in buildings and in industry for fireproofing, thermal insulation, and acoustic insulation. Chrysotile was also used to reinforce materials to improve fracture and bending characteristics. A large proportion of the chrysotile produced was used in asbestos-cement products. These include flat sheets, tiles and corrugated sheets for roofing, pipes and open troughs for the collection of rainwater, as well as pressure pipes for supply of potable water. Chrysotile was also incorporated into products such as decorative coatings and plasters, glues, sealants and resins, floor tiles, gaskets, and road paving. In some products, chrysotile was incorporated to modify rheological properties, e.g. in the manufacture of ceiling tile panels and oil drilling muds. Long textile grade chrysotile fibre was also used to manufacture woven, spun, felted and paper products.

Amosite and crocidolite accounted for almost all of the remaining asbestos use. Amosite was widely used as fireproofing and in thermal insulation products, e.g. pipe coverings and insulating boards. Crocidolite was also used as fireproofing and in thermal insulation products, but was particularly prized because it is highly resistant to acids, flexible enough to be spun and has high tensile strength for reinforcement. Crocidolite found application as a reinforcing fibre in acid containers such as those used for lead-acid batteries, in high-performance textiles and gaskets, and was particularly important for the manufacture of high-pressure asbestos cement pipes for delivery of potable water.

Three other types of asbestos are currently regulated. Materials containing commercial anthophyllite are relatively rare, but they have also been used as a filler and reinforcing fibre in composite materials, and as a filtration medium. Tremolite asbestos and actinolite asbestos were not extensively used commercially, but some occurrences of tremolite asbestos in surfacing materials and fireproofing have been found in Japan. Tremolite asbestos and actinolite asbestos sometimes occur as contaminants of other commercial minerals. Other minerals can also occur as asbestos. For example, richterite asbestos and winchite asbestos occur at mass fractions between 0,1 % and 6 % associated with vermiculite, formerly mined at Libby, Montana, USA. Vermiculite from this source was widely distributed and is often found as loose fill insulation and as a constituent in a range of construction materials and fireproofing.

While the asbestos mass fraction in some products can be very high and in some cases approach 100 %, in other products the mass fractions of asbestos used were significantly lower and often between 1 % and 15 %. In some ceiling tile panels, the mass fraction of asbestos used was close to 1 %. There are only a few known materials in which the asbestos mass fraction used was less than 1 %. Some adhesives, sealing compounds and fillers were manufactured in which asbestos mass fractions were lower than 1 %. There are no known materials in which asbestos was intentionally added at mass fractions lower than 0,1 %.

In this part of ISO 22262, procedures for collection of samples and qualitative analysis of commercial bulk materials for the presence of asbestos are specified. The primary method used to identify asbestos is polarized light microscopy. Because of the wide range of matrix materials into which asbestos was incorporated, polarized light microscopy cannot provide reliable analysis of all types of asbestos-containing materials in untreated samples. The applicability of polarized light microscopy can be extended by the use of simple treatments such as ashing and treatment with acid. Optionally, either scanning electron microscopy or transmission electron microscopy may be used as an alternative or confirmatory method to identify asbestos.

Although this part of ISO 22262 specifies that, optionally, a visual estimate of the asbestos mass fraction within very broad ranges may also be made, it is recognized that the accuracy and reproducibility of such estimates is very limited. Quantitative determination of the asbestos content can be needed for a number of reasons, e.g. assessment and management of the risk from asbestos materials in buildings or to comply with regulatory definitions for asbestos-containing materials. The necessity to quantify asbestos in a material depends on the maximum mass fraction that has been adopted by the jurisdiction to define an asbestos-containing material for the purpose of regulation. Definitions range from "any asbestos" to 0,1 %, 0,5 % or 1 %. For jurisdictions in which an asbestos-containing material is defined as one containing "any asbestos", a particular problem is how to determine whether a material does not contain asbestos, since all methods have limits of detection.

ISO 22262-1:2012(E)

For practical purposes, since no known commercial materials exist in which commercial asbestos was intentionally added at mass fractions lower than 0,1 %, this part of ISO 22262 specifies that samples be classified as asbestos-containing (i.e. containing more than 0,1 % asbestos) if either chrysotile, amosite, crocidolite or anthophyllite, or any of these varieties in combination, is detected in the analysis. When the definition of an asbestos-containing material is either 0,5 % or 1 %, depending on the nature of the product, it is often necessary to proceed to other parts of this International Standard in order to quantify the asbestos for the purpose of defining the regulatory status of the material.

The occurrence of tremolite, actinolite or richterite/winchite in a material is usually a consequence of natural contamination of the constituents, and the detection of these minerals does not necessarily indicate that the mass fraction is more than 0,1 % asbestos. Accordingly, determination of the regulatory status of these materials by any of the criteria can often be achieved only by quantitative analysis. Since these minerals were not specifically mined and utilized for their fibrous properties, they may also occur in materials as either non-asbestiform or asbestiform analogues, or as mixtures of both. Evaluation of these types of material may require a more detailed analysis.

Simple analytical procedures such as polarized light microscopy are not capable of detecting or reliably identifying asbestos in some types of commercial products containing asbestos, either because the fibres are below the resolution of optical microscopy or because the matrix material adheres too strongly to the fibres. For these types of product, it may be necessary to utilize electron microscopy.

For a list of parts of this International Standard, see the Foreword.

The method specified in this part of ISO 22262 is based on MDHS 77,^[11] VDI 3866 Part 1,^[13] VDI 3866 Part 4,^[14] VDI 3866 Part 5,^[15] AS 4964-2004,^[8] EPA/600/R-93/116,^[10] and NF X46-020:2008.^[12]

Air quality — Bulk materials — Part 1: Sampling and qualitative determination of asbestos in commercial bulk materials

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This part of ISO 22262 specifies methods for sampling bulk materials and identification of asbestos in commercial bulk materials. This part of ISO 22262 specifies appropriate sample preparation procedures and describes in detail the procedure for identification of asbestos by polarized light microscopy and dispersion staining.

This part of ISO 22262 also specifies simple procedures for separation of asbestos fibres from matrix materials such as asphalt, cement, and plastics products. Optionally, identification of asbestos can be carried out using scanning electron microscopy or transmission electron microscopy with energy dispersive X-ray analysis. Information is also provided on common analytical problems, interferences and other types of fibre that may be encountered in the analysis.

This part of ISO 22262 is applicable to qualitative identification of asbestos in specific types of manufactured asbestos-containing products and commercial minerals. This part of ISO 22262 is applicable to the analysis of fireproofing, thermal insulation, and other manufactured products or minerals in which asbestos fibres can readily be separated from matrix materials for identification.

NOTE This part of ISO 22262 is intended for use by microscopists who are familiar with polarized light microscopy methods and the other analytical procedures specified (References [16]–[19]). It is not the intention of this part of ISO 22262 to provide instruction in the fundamental analytical techniques.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1

achromat

microscope objective in which chromatic aberration is corrected for two wavelengths and spherical aberration and other aperture-dependent defects are minimized for one other wavelength (usually about 550 nm)

EXAMPLE One wavelength less than about 500 nm, the other greater than about 600 nm.

NOTE This term does not imply any degree of correction for curvature of image field; coma and astigmatism are minimized for wavelengths within the achromatic range.

[ISO 10934-1:2002,^[3] 2.6]

2.2

acicular

shape shown by an extremely slender crystal with cross-sectional dimensions which are small relative to its length, i.e. needle-like

[ISO 13794:1999,^[4] 2.1]

2.3

alpha refractive index

α

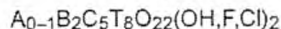
lowest refractive index exhibited by a fibre

ISO 22262-1:2012(E)

2.4

amphibole

group of rock-forming ferromagnesium silicate minerals, closely related in crystal form and composition, and having the nominal formula:



where

A is K, Na

B is Fe^{2+} , Mn, Mg, Ca, Na

C is Al, Cr, Ti, Fe^{3+} , Mg, Fe^{2+}

T is Si, Al, Cr, Fe^{3+} , Ti

NOTE In some varieties of amphibole, these elements can be partially substituted by Li, Pb, or Zn. Amphibole is characterized by a cross-linked double chain of Si-O tetrahedra with a silicon:oxygen ratio of 4:11, by columnar or fibrous prismatic crystals and by good prismatic cleavage in two directions parallel to the crystal faces and intersecting at angles of about 56° and 124°.

[ISO 13794:1999,^[4] 2.2]

2.5

amphibole asbestos

amphibole in an asbestiform habit

[ISO 13794:1999,^[4] 2.3]

2.6

analyser

polar used after the object to determine optical effects produced by the object on the light, polarized or otherwise, with which it is illuminated

NOTE It is usually positioned between the objective and the primary image plane.

[ISO 10934-1:2002,^[3] 2.117.1]

2.7

anisotropy

state or quality of having different properties along different axes

EXAMPLE An anisotropic transparent particle can show different refractive indices with the vibration direction of incident light.

2.8

asbestiform

specific type of mineral fibrosity in which the fibres and fibrils possess high tensile strength and flexibility

[ISO 13794:1999,^[4] 2.6]

2.9

asbestos

term applied to a group of silicate minerals belonging to the serpentine and amphibole groups which have crystallized in the asbestiform habit, causing them to be easily separated into long, thin, flexible, strong fibres when crushed or processed

NOTE 1 The Chemical Abstracts Service Registry Numbers of the *most common* asbestos varieties are: chrysotile (12001-29-5), crocidolite (12001-28-4), grunerite asbestos (amosite) (12172-73-5), anthophyllite asbestos (77536-67-5), tremolite asbestos (77536-68-6) and actinolite asbestos (77536-66-4).

[ISO 13794:1999,^[4] 2.7]

NOTE 2 Other varieties of asbestiform amphibole, such as richterite asbestos and winchite asbestos (Reference [20]), are also found in some products such as vermiculite and talc.

2.10

aspect ratio

ratio of length to width of a particle

[ISO 13794:1999,^[4] 2.10]

2.11

Bertrand lens

intermediate lens which transfers an image of the back focal plane of the objective into the primary image plane

NOTE The Bertrand lens is used for conoscopic observation in polarized light microscopy and for adjustment of the microscope illuminating system, especially in phase-contrast and modulation-contrast microscopy.

[ISO 10934-1:2002,^[3] 2.87.2]

2.12

birefringence

quantitative expression of the maximum difference in refractive index due to double refraction

[ISO 10934-1:2002,^[3] 2.16]

2.13

camera length

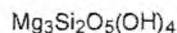
equivalent projection length between the specimen and its electron diffraction pattern, in the absence of lens action

[ISO 13794:1999,^[4] 2.12]

2.14

chrysotile

fibrous mineral of the serpentine group which has the nominal composition:



NOTE Most natural chrysotile deviates little from this nominal composition. In some varieties of chrysotile, minor substitution of silicon by Al^{3+} may occur. Minor substitution of magnesium by Al^{3+} , Fe^{2+} , Fe^{3+} , Ni^{2+} , Mn^{2+} and Co^{2+} may also be present. Chrysotile is the most prevalent type of asbestos.

[ISO 13794:1999,^[4] 2.13]

2.15

cleavage

breaking of a mineral along one of its crystallographic directions

[ISO 13794:1999,^[4] 2.14]

2.16

cleavage fragment

fragment of a crystal that is bounded by cleavage faces

NOTE Crushing of non-asbestiform amphibole generally yields elongated fragments that conform to the definition of a fibre, but rarely have aspect ratios exceeding 30:1.

2.17

crossed polars

state in which the polarization directions of the polars (polarizer and analyser) are mutually perpendicular

[ISO 10934-1:2002,^[3] 2.117.2]

ISO 22262-1:2012(E)

2.18

***d*-spacing**

distance between identical adjacent and parallel planes of atoms in a crystal

[ISO 13794:1999,^[4] 2.18]

2.19

dispersion

variation of refractive index with wavelength of light

[ISO 7348:1992,^[1] 05.03.26]

2.20

dispersion staining

effect produced when a transparent object is immersed in a surrounding medium, the refractive index of which is equal to that of the object at a wavelength in the visible range, but which has a significantly higher optical dispersion than the object

NOTE Only the light refracted at the edges of the object is imaged, and this gives rise to colours at the interface between the object and the surrounding medium. The particular colour is a measure of the wavelength at which the refractive index of the object and that of the medium are equal.

2.21

electron diffraction

technique in electron microscopy by which the crystal structure of a specimen is examined

[ISO 13794:1999,^[4] 2.19]

2.22

electron scattering power

extent to which a thin layer of substance scatters impinging electrons from their original directions

[ISO 13794:1999,^[4] 2.20]

2.23

energy dispersive X-ray analysis

EDXA

measurement of the energies and intensities of X-rays by use of a solid-state detector and multichannel analyser system

[ISO 13794:1999,^[4] 2.22]

2.24

eucentric

condition in which the area of interest of an object is placed on a tilting axis, at the intersection of the electron beam with that axis, and is in the plane of focus

[ISO 13794:1999,^[4] 2.23]

2.25

extinction

condition in which an optically anisotropic object appears dark when observed between crossed polars

[ISO 10934-1:2002,^[3] 2.51]

NOTE Extinction occurs when the vibration directions of the crystal are parallel to the vibration directions in the polarizer and analyser.

2.26

extinction angle

angle between the extinction position and the position at which the length of a fibre is parallel to the polarizer or analyser vibration directions

2.27

fibril

single fibre of asbestos which cannot be further separated longitudinally into smaller components without losing its fibrous properties or appearances

[ISO 13794:1999,^[4] 2.25]

2.28

fibre

elongated particle which has parallel or stepped sides

[ISO 13794:1999,^[4] 2.26]

NOTE For the purposes of this part of ISO 22262, a fibre is defined to have an aspect ratio greater than or equal to 3:1.

2.29

fibre bundle

structure composed of parallel, smaller diameter fibres attached along their lengths

NOTE A fibre bundle may exhibit diverging fibres at one or both ends.

[ISO 13794:1999,^[4] 2.27]

2.30

gamma refractive index

γ

highest refractive index exhibited by a fibre

2.31

habit

characteristic crystal growth form, or combination of these forms, of a mineral, including characteristic irregularities

[ISO 13794:1999,^[4] 2.30]

2.32

high-efficiency particulate air filter

HEPA

filter that is at least 99,97 % efficient by volume on 0,3 μm particles

[ISO 14952-1:2003,^[6] 2.13]

2.33

isotropic

having the same properties in all directions

[ISO 14686:2003,^[5] 2.23]

2.34

Köhler illumination

method of illuminating specimens in which an image of the illumination source is projected by a collector into the plane of the aperture diaphragm in the front focal plane of the condenser, which then projects an image of an illuminated field diaphragm at the opening of the collector into the specimen plane

2.35

lamda zero

λ_0

matching wavelength corresponding to the dispersion staining colour shown by a particle in an immersion medium

NOTE At this wavelength, the particle and the immersion medium have the same refractive index.

ISO 22262-1:2012(E)

2.36

matrix

material in a laboratory sample within which fibres are dispersed

2.37

Miller index

set of either three or four integer numbers used to specify the orientation of a crystallographic plane in relation to the crystal axes

[ISO 13794:1999,^[4] 2.33]

2.38

pleochroism

property of an optically anisotropic medium by which it exhibits different brightness and/or colour for different directions of light propagation, or for different vibrations, on account of variation in selective spectral absorption of transmitted light

2.39

polarized light

light in which the vibrations are partially or completely suppressed in certain directions at any given instant

NOTE The vector of vibration may describe a linear, circular or elliptical shape.

[ISO 10934-1:2002,^[3] 2.88.1]

2.40

polarizer

polar placed in the light path before the object

[ISO 10934-1:2002,^[3] 2.117.4]

2.41

polar

device which selects plane-polarized light from natural light

[ISO 10934-1:2002,^[3] 2.117]

2.42

refractive index

n

ratio of the speed of light (more exactly, the phase velocity) in a vacuum to that in a given medium

[ISO 10934-1:2002,^[3] 2.124]

2.43

retardation

difference in optical path length expressed in wavelengths, length units or phase angles between two mutually perpendicular plane-polarized waves

[ISO 10934-1:2002,^[3] 2.128]

2.44

selected area electron diffraction

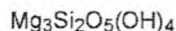
technique in electron microscopy in which the crystal structure of a small area of a sample is examined

[ISO 13794:1999,^[4] 2.38]

2.45

serpentine

group of common rock-forming minerals having the nominal formula:



[ISO 13794:1999,[4] 2.39]

2.46

sign of elongation

description of the directions of the high and low refractive indices in a fibre

NOTE The fibre is described as positive when the higher refractive index is parallel to the length of the fibre, and negative when the lower refractive index is parallel to the length of the fibre.

2.47

temperature coefficient of refractive index

measure of the change of refractive index of a substance with temperature

2.48

twinning

occurrence of crystals of the same species joined together at a particular mutual orientation, and such that the relative orientations are related by a definite law

[ISO 13794:1999,[4] 2.41]

2.49

unopened fibre

large diameter asbestos fibre bundle that has not been separated into its constituent fibrils or fibres

[ISO 13794:1999,[4] 2.42]

2.50

zone-axis

line or crystallographic direction through the centre of a crystal which is parallel to the intersection edges of the crystal faces defining the crystal zone

[ISO 13794:1999,[4] 2.43]

3 Symbols and abbreviated terms

$\frac{dn}{dT}$	change of RI of an immersion medium per degree Celsius change of temperature
n_D^{25}	RI of a liquid for the sodium D line (589,3 nm) and at a temperature of 25 °C
α	lowest RI of an anisotropic particle
β	intermediate RI of an anisotropic particle
γ	highest RI of an anisotropic particle
λ_0	wavelength at which the RI of a particle is equal to the RI of the liquid in which it is immersed
ED	electron diffraction
EDXA	energy dispersive X-ray analysis
FWHM	full width, half maximum

ISO 22262-1:2012(E)

HEPA	high-efficiency particle absolute
MEC	mixed esters of cellulose
PC	polycarbonate
PCOM	phase contrast optical microscopy
PLM	polarized light microscopy
RI	refractive index
SAED	selected area electron diffraction
SEM	scanning electron microscopy
TEM	transmission electron microscopy

4 Principle

4.1 General

A suitable tool is used, in compliance with the relevant safety regulations, to take a sample from the material to be analysed. The sample is then appropriately packed and labelled for transportation to the laboratory.

A representative sample of the bulk material is initially examined using a stereo-binocular microscope. Typical fibres are removed using tweezers and mounted in appropriate liquid immersion media on slides for examination by polarized light microscopy. Asbestos fibres are identified based on morphology, colour, pleochroism, and the α (lowest) and γ (highest) refractive indices qualitatively assessed using the dispersion staining technique. Detection of commercial asbestos (chrysotile, amosite, crocidolite or anthophyllite), either alone or in combination, is assumed to indicate that the asbestos is present at a mass fraction exceeding 0,1 %. Optionally, a visual estimate of the asbestos mass fraction is reported in one of several broad mass fraction ranges. Tremolite, actinolite and richterite/winchite are identified by the same procedure, but since they are usually present as contaminants of mineral products, detection of these minerals does not provide information as to their minimum mass fraction. Optionally, fibres may be identified by SEM or TEM.

4.2 Substance determination

This International Standard specifies a number of reference methods for determination of asbestos in solid materials. This part of ISO 22262 provides a method for qualitative analysis of specific commercial products for the presence of asbestos (chrysotile, amosite, crocidolite, tremolite, actinolite, anthophyllite and richterite/winchite). Other parts of this International Standard provide methods for the analysis of specific types of commercial products for which the use of PLM on the untreated sample yields unacceptable rates of error, and for the quantification of asbestos in the low mass fraction range below approximately 5 %.

4.3 Type of sample

The method specified in this part of ISO 22262 is applicable to sampling and analysis of commercial products from which individual fibres of asbestos can be manually separated from the matrix material, either by picking fibres from surfaces and newly fractured surfaces, or after chemical treatments, acid extraction or ashing, such that the fibres can be identified by one of the specified identification methods. This part of ISO 22262 is generally applicable to asbestos-containing building materials such as fireproofing, thermal pipe and boiler insulations, asbestos cement, plasters, roofing, and other similar materials. The method is also applicable to the identification of asbestos in a range of other industrial minerals and materials.

4.4 Range

Experience from proficiency testing has shown that the range of this part of ISO 22262, when it is applied to a suitably prepared sample in which the asbestos fibres are sufficiently large to be optically visible using a low-

magnification stereomicroscope, is from less than 0,1 % to 100 %. The lower end of the range can be extended downwards by use of appropriate techniques.

4.5 Limit of detection

The limit of detection of this method is defined as the detection and identification of one fibre or fibre bundle in the amount of sample examined. The limit of detection that can be achieved depends on:

- a) the nature of the matrix of the sample;
- b) the size of the asbestos fibres and bundles;
- c) the use of appropriate sample preparation and matrix reduction procedures;
- d) the amount of time expended on examination of the sample;
- e) the method of analysis used — PLM, SEM or TEM.

With appropriate matrix reduction procedures that are tailored to the nature of the sample, the limit of detection can be significantly lower than 0,01 %.

4.6 Limitations of PLM in the detection of asbestos

The ability to detect and identify asbestos by PLM is limited by the resolution of the optical microscope and sometimes by the masking effects of other materials that comprise the balance of the sample. Asbestos fibres with widths below approximately 0,2 µm are unlikely to be detected by PLM. However, for all varieties of amphibole asbestos, and most varieties of chrysotile, a large proportion of the mass comprises fibres that exceed this width and, because of this, asbestos can be reliably detected by PLM. Accordingly, provided that the nature of the matrix material on the microscope preparation is such that it does not obscure any asbestos fibres that might be present, a non-detected result by PLM indicates that the mass fraction of asbestos is below the limit of detection.

One commercial source of chrysotile presents problems of detection by PLM. Chrysotile originating from the Coalinga deposit in California, USA, contains no fibrils longer than approximately 30 µm and, if these are well dispersed in a sample matrix, the majority of the chrysotile is below the size that can be reliably detected and identified by PLM. The range of application of Coalinga chrysotile is limited to floor tiles, ceiling tiles, drywall joint compounds, mastics, paints, sealants, adhesives, drilling mud, moulded cement building products, and as filler in some plastics. There is a high probability that this variety of chrysotile may not be detected by PLM, even when present in high mass fractions. The size distribution of Coalinga chrysotile makes it unsuitable for most other applications in which asbestos was used and the possibility that it will be encountered in other types of product can generally be discounted. If, on the basis of PLM examination, Coalinga chrysotile is suspected to be present, it is recommended that the sample be examined by electron microscopy.

Asbestos fibres may not be detected by PLM because they are obscured by the matrix of the sample. The matrix reduction methods specified in this part of ISO 22262 are intended to minimize the possibility of failing to detect asbestos in such samples.

5 Sample collection

5.1 Requirements

5.1.1 Sampling apparatus. Depending on the nature of the material to be sampled, an appropriate tool is required for collection of the sample. If the material is soft, such as thermal insulation or fireproofing, a knife or scalpel may be sufficient. In other situations, a cork borer may be used to sample all of the layers of a layered material. If the material is hard, e.g. asbestos-cement, tools such as pliers, a wire cutter, hammer and chisel or rotating hole saw can be needed.

ISO 22262-1:2012(E)

5.1.2 HEPA vacuum cleaner. A HEPA vacuum cleaner, approved for asbestos, is required for cleaning around the sampling location after collection of the sample to minimize dispersion of asbestos-containing dust or particulate matter.

5.1.3 Materials and supplies for sampling.

5.1.3.1 Wetting agent. A wetting agent may be used to limit the generation of airborne dust during the collection of the sample. Water, or water to which a small amount of surfactant has been added, may be applied to the surface before sampling using a spray bottle or brush.

IMPORTANT If a sample is being collected for the purpose of product identification, use no wetting agent, since this may result in alteration of the sample composition by addition of surfactant, and by dissolution and loss of water-soluble constituents.

5.1.3.2 Filler. After collection of the sample, a minor repair may be necessary to seal the damaged area. Depending on the circumstances, spray paint, touch-up paint or plaster may be used.

5.1.3.3 Sample containers. Appropriate dust-tight containers are required for packaging the sample. Plastic bags with "zip" closures or bottles with screw caps may be used.

5.1.3.4 Labels. A method for labelling samples is required. Self-adhesive paper labels may be used. Alternatively, a waterproof marker may be sufficient for field use.

5.1.3.5 Dust mask. A dust mask with filter approved for respiratory protection against airborne asbestos fibres. Approved filters conform to either the National Institute for Occupational Safety and Health (NIOSH) P100 or the European Standard EN 143^[9] P3 specification. Other types of personal protective equipment may be used if warranted by the situation.

5.1.3.6 Light. Either a flashlight or an appropriate light source is required for collection of samples in dark locations.

5.1.3.7 Plastic bags. Labelled plastic bags of appropriate size that can be closed tightly and are required to collect the waste generated during sampling. Bags containing waste should be placed inside another tightly closed plastic bag.

5.1.3.8 Cleaning supplies. Cleaning materials, such as disposable paper towels and a supply of water, are required for cleaning sampling tools to avoid cross-contamination between samples.

5.1.3.9 Location identifiers. The use of some means of identifying the precise location from which each sample is taken is recommended, since it may be necessary to resample the material at a later date to resolve discrepancies if they arise. A location identifier is invaluable if the sample collected is found not to be representative of the overall area, such as if the sample has been taken from a patch in a location that has been repaired. A specific colour of spray paint, or appropriate permanent labels applied to the precise location, may be used.

5.2 Procedure

5.2.1 Safety precautions

Handling asbestos is regulated by many jurisdictions, and regulations often specify a variety of procedures to ensure that individuals performing work and those in close proximity are not exposed to excessive concentrations of airborne asbestos. Exceptions from the regulations are generally permitted for some types of activity that are minimally invasive, such as the removal of material samples for analysis.

IMPORTANT—Care is necessary during sampling of materials that may contain asbestos, and precautions should be taken to avoid creating and inhaling airborne asbestos particles when sampling materials suspected of containing asbestos. If the handling instructions in this clause are followed, it may be

assumed that the level of dust meets the thresholds of safety defined in the regulations. In exceptional cases, more extensive precautions may be necessary to prevent the release of airborne fibres.

Sometimes different materials may have been applied to a surface as several layers. It is recommended that samples of all of the individual layers be collected. If a borer or hole-sawing device is used to penetrate several layers, the device should be operated so that it rotates slowly. This ensures that only coarse turnings are produced. High-speed devices are not recommended, since it is then necessary to take more complex safety precautions such as local suction and filtration to collect the dust generated.

5.2.2 Sample size requirements

5.2.2.1 General

Although only a few milligrams of sample are required for the analytical methods specified, it is necessary to take into account the homogeneity of the material, and to ensure that the sample is of sufficient size to be representative of the material under investigation. If inspection shows that the material is finely divided and homogeneous when examined visually, or if the nature of the material is recognized as such from previous knowledge, a minimum sample size of approximately 1 cm³ generally provides sufficient material for analysis. However, a minimum volume of 10 cm³ is recommended for materials such as sprayed fireproofing, and as much as 1 000 cm³ for materials such as loose-fill vermiculite.

5.2.2.2 Representative sample

A wide range of asbestos-containing materials was used in the past. Experience is very valuable in the selection of the materials to be sampled and sampling can be facilitated by the use of all available prior knowledge about the materials or components from which the sample is being collected. It is essential that the sample collected be representative of the composition of the product with respect to its asbestos content. Although many asbestos-containing materials may seem to be homogeneous when visually examined, they can be quite inhomogeneous in the microscopic size range. This is particularly the case for materials such as texture coats, in which the fragments of aggregate are significantly larger than the other constituents of the material.

In some types of material, particularly those that have been mixed at a building site, rather than a commercial product manufactured and mixed under a formulation and quality control procedure, the asbestos may not be distributed homogeneously within the material. For these types of materials, it is necessary to collect a larger sample to ensure that the sample is representative of the material.

It is recommended that a portion of the sample be archived, because further examination of the sample is often the only way in which potential questions can be resolved.

In addition to the problem of inhomogeneity, the possibility that repairs using materials from different sources may have occurred needs to be considered. For example, during renovation or repairs, some asbestos-free ceiling tiles may have been installed in a suspended ceiling, the balance of which contain asbestos, for no other reason than such ceiling tiles were readily available at the time. During repairs or rebuilding, other materials of the same appearance, but having different compositions, may have been used to repair damage to fireproofing, thermal insulation or bulkheads.

It is important to recognize that the analytical result relates only to the actual sample tested. If the sample collected is not representative, the result will not be representative of the material.

Annex A, which lists the asbestos-containing materials most frequently used, provides guidance for identifying different types of material.

5.2.2.3 Number of samples

The number of samples to be taken is dependent on the nature of the material, whether the material is homogeneous or inhomogeneous, and the size of the area under consideration. In the case of materials known from prior experience to be homogeneous, it may be sufficient to collect one sample, although collection of more than one sample provides additional confidence that the results are representative of the material being sampled. When materials are suspected to be inhomogeneous, it is necessary to collect several samples and

ISO 22262-1:2012(E)

to ensure that each of the samples is of sufficient size. If it is intended to determine the range of asbestos content in an area of material, it is necessary to analyse all of the samples individually. Otherwise, such samples may be combined before analysis in order to ensure that the sample analysed represents the mean asbestos mass fraction of the material.

5.2.2.4 Precautions to avoid cross-contamination between samples

It is most important that precautions be taken to ensure that cross-contamination of samples does not occur. Clean all tools used for collecting samples prior to initial use and again after collection of each sample. Use a new and unused container or plastic bag for each sample, and double-bag each sample.

5.2.2.5 Sampling strategy

Selection of the sampling locations depends on the type of area being sampled and on the nature of the product suspected to contain asbestos.

The selection of the sampling locations shall be made in accordance with any national regulations.

The material being sampled may be known to be homogeneous, e.g. a manufactured packing material or sheet material. Samples should be collected at locations that are as inconspicuous as possible. Locations that exhibit prior superficial damage or locations behind readily detached covers are particularly suitable, provided that there are no reasons to suspect that the material in such locations is not representative.

IMPORTANT — Ensure that the sampling location is not at a position where repair using a different material has previously occurred.

If the material under test has a layered structure, e.g. in the case of multilayer pipe insulations or multilayer floor coverings, include all layers of the material in the collected sample. Include any coverings or adhesive layers, such as coatings or glues. Do not attempt to separate the layers under field conditions; separation of individual layers for analysis is best performed under controlled conditions in the laboratory.

If the product under test is behind a wall cladding or other covering, power sockets or light switch recesses are frequently suitable as locations for collection of material samples. If it is not possible to gain access in this manner, it is necessary to cut the claddings or coverings open in order to enable sample collection. These openings should be made at a location that detracts from the visual appearance as little as possible, e.g. behind baseboards.

5.2.2.6 Taking the samples

Release of airborne asbestos fibres from asbestos-containing materials may occur before or during the sampling. The use of containment measures may be necessary. If the material is such that a significant release of airborne asbestos fibres may occur during collection of the sample, sample carefully and moisten the sampling location with water from a spray bottle, a water-soaked brush or a moist paper towel. A moist paper towel is also useful to clean contaminated surfaces after the sample has been collected.

Water should not be used if samples are being collected in the vicinity of operating electrical equipment.

- a) For many types of homogeneous material, it is usually possible to collect small amounts of sample without visibly defacing the material and without incurring any significant release of airborne fibres.
- b) If the material appears to be homogeneous, collect a sample area more than 1 cm² in the case of thin materials, or a volume greater than 1 cm³ in the case of materials having a thickness of several centimetres. Remove the sample by breaking it off with pincers or preferably using a sharp cutting tool. If the material appears to be inhomogeneous, collect a sufficient amount of sample to give confidence that the volume of sample is representative of the material.
- c) Place each sample in an individual dust-tight container.
- d) Wipe the sampling site and the immediate surroundings, keeping them moist, or clean the area around the sample location using a vacuum cleaner with a HEPA filter.

- e) If necessary, seal the exposed surface from which the sample was taken using touch-up paint, glue or other appropriate sealant.
- f) Affix, if applicable and agreed to by the facility administration, a permanent identification marker to the exact location from which the sample is removed.

5.2.2.7 Sample labelling

Label the sample container clearly, either by using a permanent marker pen or by attaching a permanent adhesive label. Confirm that the sample label corresponds to the information on any identification marker affixed to the sampling location.

5.2.2.8 Sampling record

Make a record of the sample that contains at least the following information:

- a) full description of the type of material;
EXAMPLE Thermal insulation, board, floor tile.
- b) all details recorded on the sample label;
- c) precise description of the sampling location;
- d) building identification;
- e) identification of the room (if applicable);
- f) location in the room from which the sample was collected;
- g) the date that the sample was collected;
- h) the name of the person who collected the sample;
- i) whether the sample is a composite derived from the combination of separately collected samples;
- j) whether the sample is a multilayer sample — for multilayer samples, the positions of each of the relevant layers shall be noted.

If the sampling location is not adequately specified by the details specified in a) to f), then, in addition:

- k) make a sketch or take a photograph (record the number of the photograph); or, record the position from which the sample was taken on a plan of the building (the drawing identification shall also be noted in the record);
- l) report any other relevant data that are available with respect to the sample.

An example of a suitable sampling record is shown in Annex G.

5.2.2.9 Chain of custody

If there is any possibility that the results of sampling and analysis will be subject to litigation or legal scrutiny, it is most important that records be made of all transfers of samples between individuals, starting with the individual who collected the samples through to acceptance of the samples by the analyst. A chain of custody form shall be used for this purpose, on which the date of each transfer and the name of each individual who has relinquished or accepted possession of the samples are recorded.

5.2.2.10 Storage and transport

The samples shall be packaged in dust-tight containers (double if necessary) and a label shall be affixed to the package of samples, indicating that they may contain asbestos. Take care to ensure that unauthorized persons do not have access to the samples. There are no special requirements with respect to climate conditions

ISO 22262-1:2012(E)

for storage and transport of the samples. After the samples have been analysed, they shall be archived for whatever period of time is specified by the individual submitting them to the analytical laboratory.

6 Sample preparation

6.1 General

It is sometimes not possible to identify asbestos in bulk materials because of interference by other constituents, either because the mass fraction of asbestos is too low or because the asbestos is so inhomogeneously distributed that a large amount of the sample would need to be examined in order to reliably detect the asbestos that is present. In these cases, various chemical or physical preparation methods can be used prior to the microscopic examination to remove a large proportion of the non-asbestos constituents, thus facilitating the detection of asbestos in the smaller amount of material that remains.

6.2 Removal of organic materials by ashing

Chrysotile is often difficult to detect when mixed with large amounts of cellulose, or if it is well dispersed in organic matrices such as asphalt or poly(vinyl chloride) (PVC). Also, some other organic fibres such as spider webs and wool have optical properties similar to those of chrysotile. Ashing of the sample at a temperature of 485 °C for a period of approximately 10 h removes the organic constituents with very little effect on the optical properties of chrysotile. Although the colour and optical properties of amosite and crocidolite are altered by this oxidation treatment as a consequence of conversion of some ferrous iron [Fe(II)] to ferric iron [Fe(III)], many of the fibres can often still be identified by PLM. The optical properties of tremolite, actinolite, anthophyllite and richterite/winchite are almost unaffected by this treatment. The heat treatment does not otherwise affect the composition of any of the asbestos varieties, and they can all be identified by electron microscopy after the treatment.

6.3 Removal of soluble constituents by acid treatment

Matrix constituents such as calcite and gypsum often coat asbestos fibres so that their optical properties cannot be reliably examined. These constituents also often constitute a large proportion of the sample mass. Stirring of a sample in 2 mol/l hydrochloric acid for approximately 15 min removes many matrix constituents, and this improves the ability to identify and quantify asbestos. The acid treatment slightly reduces the refractive indices of chrysotile, and it is necessary to account for this when identifying chrysotile by PLM. Do not heat chrysotile in acid at temperatures exceeding 60 °C. This acid treatment does not affect the optical properties of any of the other asbestos varieties.

6.4 Sedimentation and flotation

Some materials contain large sizes of aggregate or sand that can be separated in water suspension by sedimentation or flotation. A large proportion of constituents such as vermiculite or perlite can be separated by flotation. Sand or small solid aggregate sediment in water much more rapidly than most of the asbestos, and in some samples a large proportion of the sand or aggregate can be separated from the fraction that contains any asbestos.

6.5 Combination of gravimetric reduction procedures

The procedures specified in 6.2, 6.3 and 6.4 may be combined as appropriate for the particular sample.

It is generally recommended that the procedures be used sequentially in the order given.

7 Analysis by PLM

7.1 Requirements

7.1.1 Stereo-binocular microscope, for initial observation of samples. The examination is facilitated if the microscope has a continuous range of magnification from approximately 10× to 40×.

7.1.2 Polarized light microscope, capable of Köhler (or Köhler-type) illumination is needed for fibre identification. The following optical accessories are necessary:

- a) light source with blue "daylight" filter;
- b) focusing sub-stage condenser with a numerical aperture (NA) greater than or equal to that of the objective in use, with a field-limiting adjustable aperture;
- c) focusing ocular with magnification of 10 times or 12 times, with a cross-hair graticule;
- d) strain-free objectives with magnifications of 4 times, 10 times, and 40 times or similar magnifications;
- e) polarizer and removable analyser, the vibration directions of which can be adjusted such that they are at 90° to each other, and can be aligned with the cross-hair in the focusing ocular;
- f) slot between the polarizer and analyser to allow accessory plates to be inserted at an angle of 45° to the polarizer and analyser vibration directions;
- g) removable retardation plate with approximately 530 nm retardation, with known slow and fast vibration directions;
- h) dispersion staining objective with magnification of 10 times or 40 times, or a demonstrated functional equivalent (MDHS 77^[11]);
- i) Bertrand lens or a focusing telescopic ocular to allow observation of the back focal plane of the objective lens;
- j) level rotating specimen stage for which the centre of rotation can be centred relative to the optical axis of the microscope for each of the objective lenses.

7.1.3 Dust extract hood. Handling and manipulation of bulk materials suspected to contain asbestos shall be performed in a suitable dust extract hood, so that neither the analyst nor the laboratory environment is exposed to airborne asbestos fibres.

7.1.4 Sample preparation.

7.1.4.1 Refractive index liquids. The majority of commercial asbestos-containing products contain only chrysotile, amosite or crocidolite, or mixtures of these three types of asbestos. Identification of these three types of asbestos can be achieved using liquids of RI 1,550, 1,680 and 1,700. The RI values of these liquids are specified for light of wavelength 589,3 nm (sodium D line) at a temperature of 25 °C.

For identification of tremolite, actinolite, anthophyllite and richterite/winchite, RI liquids in the range 1,605 to 1,660 are required, at intervals of 0,005.

Suitable calibrated RI liquids are commercially available, and a set of liquids with RIs from 1,500 to 1,700, at intervals of 0,005, gives sufficient range and discrimination.

If commercially available RI liquids cannot be obtained, a set of liquids sufficient for use in this part of ISO 22262 can be prepared (References [16][21]) using common chemical reagents as specified in Table 1.

ISO 22262-1:2012(E)

Table 1 — Reagents for preparation of RI immersion media

Reagent	n_D^{25}	$\frac{dn}{dT}$
Glycerol triacetate	1,427 7	−0,000 48
Ethyl cinnamate	1,557 4	−0,000 48
Bromobenzene	1,557 0	−0,000 54
Iodobenzene	1,617 3	−0,000 54
1-Chloronaphthalene	1,630 4	−0,000 44
1-Bromonaphthalene	1,658 0	−0,000 45
1-Iodonaphthalene	1,700 4	−0,000 44
Diiodomethane	1,739 0	−0,000 70

Commercially available RI media, and the reagents listed here, should be used in accordance with applicable safety precautions.

Table 2 shows the mixtures of reagents required to prepare a set of RI immersion media. The three primary RI liquids for identification of chrysotile, amosite and crocidolite are indicated in Table 2 in bold type (1,550, 1,680 and 1,700). Tremolite, actinolite or anthophyllite can often be identified using only RI liquids 1,605 and 1,630, also indicated in Table 2 in bold type. Tremolite, actinolite or anthophyllite may be encountered in which the refractive indices are high because of increased iron mass fraction, and use of other RI liquids in Table 2 may be necessary in order to assess the refractive indices.

Table 2 — Mixtures and single compounds required for RI liquids

Liquid n_D^{25}	Liquid 1	Volume fraction, liquid 1 %	Liquid 2	Volume fraction, liquid 2 %	$\frac{dn}{dT}$
1,545	Ethyl cinnamate	90,44	Glycerol triacetate	9,56	−0,000 48
1,550	Ethyl cinnamate	94,30	Glycerol triacetate	5,70	−0,000 48
1,555	Ethyl cinnamate	98,15	Glycerol triacetate	1,85	−0,000 48
1,560	Bromobenzene	95,03	Iodobenzene	4,97	−0,000 54
1,605	Iodobenzene	79,60	Bromobenzene	20,40	−0,000 54
1,610	Iodobenzene	87,89	Bromobenzene	12,11	−0,000 54
1,615	Iodobenzene	96,19	Bromobenzene	3,81	−0,000 54
1,620	1-Chloronaphthalene	85,83	Bromobenzene	14,17	−0,000 45
1,625	1-Chloronaphthalene	92,64	Bromobenzene	7,36	−0,000 45
1,630	1-Chloronaphthalene	100	—	—	−0,000 44
1,635	1-Bromonaphthalene	78,99	Bromobenzene	21,01	−0,000 47
1,640	1-Bromonaphthalene	84,05	Bromobenzene	15,95	−0,000 46
1,645	1-Bromonaphthalene	89,11	Bromobenzene	10,89	−0,000 46
1,650	1-Bromonaphthalene	94,18	Bromobenzene	5,82	−0,000 46
1,655	1-Bromonaphthalene	99,24	Bromobenzene	0,76	−0,000 45
1,660	1-Bromonaphthalene	90,48	1-Iodonaphthalene	9,52	−0,000 45
1,680	1-Iodonaphthalene	54,31	1-Bromonaphthalene	45,69	−0,000 44
1,700	1-Iodonaphthalene	100	—	—	−0,000 44

7.1.4.2 Asbestos reference standards. Asbestos reference standards are required. Suitable sets of standards are SRM 1866¹⁾ (chrysotile, crocidolite and amosite) and SRM 1867¹⁾ (tremolite, actinolite and anthophyllite) from the US National Institute of Standards and Technology (NIST), see Table 3, or from the UK Health and Safety Executive (HSE) [Chrysotile (Canada and Zimbabwe), crocidolite, amosite, tremolite, actinolite and anthophyllite]²⁾ see Table 4. SRM 1867 tremolite and actinolite are particularly useful for qualitative discrimination between tremolite and actinolite. The International Mineralogical Association (IMA) (References [23][24]) has specified that values of the mass fraction ratio $Mg/(Mg + Fe)$ below 0,9 are defined as tremolite, and those above 0,9 are defined as actinolite. SRM 1867 tremolite has a value of 0,84, and SRM 1867 actinolite has a value of 0,94, providing reference samples representing compositions just below and just above the IMA boundary. It is important to recognize that the IMA boundary between tremolite and actinolite is only a convention within a continuum of composition in which the iron and magnesium mass fractions vary in a reciprocal manner.

Table 3 — Optical properties of SRM 1866 and SRM 1867 reference asbestos samples

Property	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
Colour	White	Grey–brown	Blue	Light brown	White	White
Pleochroism	None	Very weak	α : Blue, γ : grey	None	None	None
Birefringence	Low	Medium	Low	Medium	Medium	Medium
Sign of elongation	Positive	Positive	Negative	Positive	Positive	Positive
Extinction	Parallel	Parallel	Parallel	Parallel	16,6°	15,9°
γ	1,556	1,701	— ^a	1,636	1,634	1,639
α	1,549	1,679	— ^a	1,615	1,606	1,613

^a For crocidolite, the certificate of analysis states: "Because strong absorption in the visible light range results in anomalous dispersion characteristics that would not be useful to the analyst, no certified values of refractive index are reported for riebeckite".

Table 4 — Optical properties of HSE reference asbestos samples

Property	Chrysotile (Canada)	Chrysotile (Zimbabwe)	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite
Colour	White	White	Grey–brown	Blue	White	White	Pale green
Pleochroism	None	None	Very weak	α : Blue, γ : grey	None	None	γ : Green, α : grey
Birefringence	Low	Low	Medium	Low	Medium	Medium	Medium
Sign of elongation	Positive	Positive	Positive	Negative	Positive	Positive	Positive
Extinction	Parallel	Parallel	Parallel	Parallel	Parallel	Parallel	Parallel
γ	1,552	1,552	1,692	1,696	1,624	1,632	1,652
α	1,544	1,544	1,676	1,688	1,608	1,616	1,644

NOTE The data for the HSE reference asbestos samples notes that, "as with all natural minerals, the reference samples may contain traces of other minerals. In particular, the anthophyllite asbestos sample contains a fibrous variety of talc which may be distinguished by its ribbon-like morphology and generally lower refractive indices".

For those laboratories that are unable to obtain either the NIST or the HSE reference asbestos samples, the Union Internationale Contre le Cancer (UICC) standard reference samples of asbestos (Reference [25]) may be used, see Table 5. These samples were widely distributed internationally, and can still be obtained.

1) Example of a suitable product available commercially from the US National Institute of Standards and Technology (NIST). This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

2) Example of a suitable product available commercially from the from the UK Health and Safety Executive (HSE). See Reference [22]. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

ISO 22262-1:2012(E)

However, since the UICC samples were prepared for use in animal studies, they were milled to very small fibre sizes. Also, the UICC samples do not include either tremolite or actinolite.

Table 5 — Optical properties of UICC reference asbestos samples

Property	Chrysotile (Canada)	Chrysotile (Zimbabwe)	Amosite	Crocidolite	Anthophyllite
Colour	White	White	Grey-brown	Blue	White
Pleochroism	None	None	Very weak	α : Blue, γ : grey	None
Birefringence	Low	Low	Medium	Low	Medium
Sign of elongation	Positive	Positive	Positive	Negative	Positive
Extinction	Parallel	Parallel	Parallel	Parallel	Parallel
γ	1,545–1,560	1,553	1,701	1,702	1,620
α	1,545–1,557	1,546	1,679	1,694	1,605
NOTE 1 A range of refractive indices is quoted for the UICC Canadian chrysotile sample. This sample was prepared by blending chrysotile from a number of different mines. Fibres with refractive indices within the approximate ranges specified are present, with birefringence ($\gamma - \alpha$) approximately 0,01.					
NOTE 2 The anthophyllite sample also contains a fibrous variety of talc.					

7.1.4.3 Sample comminution equipment. An agate mortar and pestle is required for grinding samples to suitable sizes for PLM examination.

7.1.4.4 Microscope slides, 75 mm × 25 mm.

7.1.4.5 Microscope cover glasses, 22 mm × 22 mm. Match the thickness of the cover glasses with that specified by the objective lenses. A thickness of 0,17 mm is required by many commercial objectives.

7.1.4.6 Thermometer, required to measure the temperature of the microscope slide preparation during observation if accurate refractive indices of asbestos fibres are to be recorded.

7.1.4.7 Alcohol or gas burner. A laboratory burner is sometimes useful for discriminating between organic fibres and asbestos fibres.

7.1.4.8 General laboratory supplies. The following supplies and equipment, or equivalent, are required:

- glassine paper sheets, approximately 15 cm × 15 cm, for examination of samples;
- scalpel holder and replacement disposable scalpel blades;
- sampling utensils, including tweezers, needles and spatulas;
- distilled water;
- concentrated hydrochloric acid, reagent grade;
- crucibles, silica or glazed porcelain, with lids;
- Petri dishes;
- disposable pipettes;
- glass filtration assembly, 25 mm or 47 mm diameter;
- polycarbonate filters, 0,4 μ m pore size, 25 mm or 47 mm diameter.

7.1.4.9 Muffle furnace (optional). For ashing of samples to remove interfering organic constituents, a muffle furnace with a temperature range up to 500 °C and a temperature stability of ± 10 °C is recommended.

7.1.4.10 Magnetic stirrer (optional). For removal of acid-soluble interfering constituents, a magnetic stirrer with a glass or plastic-coated magnetic stir bar.

7.2 Qualitative analysis by PLM

7.2.1 Calibration

It is essential that the optical components of the PLM be fully understood by the analyst and that the analyst be familiar with the alignment procedure. The alignment of the PLM shall be confirmed prior to conducting any analyses. The designs of microscopes vary and the alignment instructions provided by the manufacturer should be followed. The critical aspects of the alignment are listed in a) to e).

- a) The illumination source and sub-stage condenser shall be adjusted so that the field-limiting aperture is in focus (Köhler or Köhler-like illumination).
- b) The centre of rotation of the specimen stage shall be aligned with the optical axis of the PLM for each of the objective lenses. This is necessary so that a particle at the centre of the field of view remains at the centre of the field of view during rotation of the stage. This condition is often achieved by centring the rotation for one objective lens, and then laterally adjusting the position of each of the other objective lenses to align their axes with the centre of the stage rotation.
- c) The vibration directions of the polarizer and analyser shall be at 90° to each other.
- d) The vibration directions of the polarizer and analyser shall accurately coincide with the directions of the cross-hair in the ocular. This can be accomplished using a well-formed birefringent crystal with a known zero extinction angle. Alternatively, orientation plates consisting of an accurately mounted crystal with a fiducial line are commercially available. If the microscope has eyepieces that can be freely rotated, fix the position of the eyepiece containing the cross-hair using adhesive tape, for example.
- e) If a mechanical stage is installed on the rotating stage, the directions of the mechanical stage should be adjusted such that the zero angular position of the rotation stage corresponds to lateral motions of the mechanical stage parallel to the polarizer and analyser directions.

On the initial set-up of the PLM, the vibration direction of the polarizer and the orientation of the vibration directions of the 530 nm retardation plate shall be determined. The vibration direction of the polarizer can be determined by examination of a slide preparation of crocidolite with the polarizer in position and the analyser withdrawn. Under these conditions, the direction of the length of the crocidolite fibres when the dark blue pleochroism is displayed is the vibration direction of the polarizer. The orientation of the vibration directions of the 530 nm retardation plate can be determined by examination of a fibre of a known reference material such as amosite or chrysotile, and observing the change of interference colour when the retardation plate is inserted. The slow vibration direction of chrysotile or amosite is parallel to the length of the fibre. If the retardation plate adds to the retardation caused by the fibre, the slow vibration directions of the fibre and the retardation plate are parallel. An interference colour chart is provided in Annex B.

Before using RI liquids for the identification of asbestos, even if certified liquids are purchased, it is recommended that the refractive indices of liquids be confirmed using reference glass samples or a refractometer. If kept tightly capped, the refractive indices of these liquids remain stable for at least 2 years. Some RI liquids degrade when exposed to light, therefore they should be stored in dark bottles, preferably in a dark place.

7.2.2 Sample preparation

For many samples, including fireproofing, thermal insulation and asbestos cement products, fibres that can be removed with tweezers are visible during stereomicroscope examination. Mount typical suspected asbestos fibres on a microscope slide and add a drop of the RI liquid appropriate for the suspected asbestos variety. If the suspected asbestos variety cannot be confirmed using the appropriate RI liquid, mount additional fibres from the sample on slides using RI liquids appropriate for the other asbestos varieties.

ISO 22262-1:2012(E)

7.2.3 Sample analysis

7.2.3.1 Analytical sequence

The analytical techniques described have been shown to give reliable and reproducible results. Alternative methods can be used if their equivalence in terms of detection and identification can be demonstrated. Identification of the asbestos fibres should be based on the following analytical sequence:

- a) make a preliminary visual examination of the whole of the laboratory sample to assess the sample type and the required sample treatment (if any) — where possible, take a representative test portion at this stage for direct examination by PLM;
- b) carry out any required sample treatment to release or isolate fibres;
- c) perform a detailed and thorough search under the stereomicroscope to classify the suspected fibre types present;
- d) mount representative fibres in appropriate RI liquids on microscope slides;
- e) identify the different fibrous components using PLM.

If no asbestos is detected by these procedures, prepare additional slides using random test portions of a few milligrams and search for thin asbestos fibres using PLM.

7.2.3.2 Preliminary examination

Examine the entire sample visually to describe the type of material or product present, and to establish whether there are visible fibres. Note the nature of any matrix materials, as this may indicate the type of treatment required for the sample. Examine the sample using the stereomicroscope. So far as possible, make an initial determination of the number of fibre types present. Record the appearance, colour and texture of the sample and any fibre types observed. For inhomogeneous or layered samples, it may be necessary to describe each separate layer or part of the sample. Sample preparation and the analysis of the sample are dependent on the quality of the initial visual examination. Also, adequate description of the appearance of the sample is important in establishing whether asbestos is present, or in which part of the sample asbestos is present.

7.2.3.3 Sample treatment

The purpose of any initial treatment of laboratory samples is to release fibres from any matrix and to remove fine particles adhering to the fibres (both of which obscure the optical effects and hinder the identification). It is necessary to break non-friable samples (with tools if necessary) and then to examine newly fractured edges using the stereomicroscope to observe any protruding fibres. If samples contain large pieces of hard materials, grinding the sample may be necessary. Surfaces and edges of hard materials may be abraded to release fibres for examination. Routine procedures used for sample treatment should be fully documented. Any deviations from these procedures for particular samples should be recorded.

Dilute acetic acid or cold dilute hydrochloric acid may be used to remove calcium carbonate (limestone), calcium sulfate (gypsum), and calcium silicate, which are commonly used as binders (e.g. for insulation and asbestos boards) and fillers (e.g. in floor tiles). The removal of calcium magnesium carbonate (dolomite) requires the use of cold concentrated hydrochloric acid. Sufficient acid should be added in small aliquots for several minutes or until effervescence stops. Fibre release may be aided by stirring or by ultrasonic treatment. The sample is then filtered and repeatedly washed with water. Residual acid may degrade the fibres and affect the optical properties, and small crystals of salts may form. The sample may be rinsed with ethanol or other volatile solvents to reduce the drying time.

Organic matrices such as plastics, asphalt, resins or rubber products may require prolonged treatment in solvents to remove the matrix. An effective solvent for any particular sample type can be established only by individual testing or by foreknowledge of the type of matrix. Organic matrices may be removed by treatment in a muffle furnace at 485 °C. However, heating may modify the optical properties of some of the asbestos fibres.

7.2.3.4 Stereomicroscope examination

The original samples or portions of sample that have undergone sample treatment should be examined using the stereomicroscope. For many asbestos-containing materials, asbestos fibres can be detected at magnifications within the range of the stereomicroscope. For other types of asbestos-containing material, it may not be possible to detect asbestos fibres using the stereomicroscope. The aim is to detect small fibre bundles, or individual fibres, and tentatively to assign fibre types based on their appearance. This is usually achieved by placing the sample on a piece of glassine paper or in a suitable container and carrying out a detailed search of the entire sample using needles or tweezers to separate the different fibrous components from the matrix. The appearance of these fibres is then noted. The care and vigilance with which the sample is examined at this stage are important in detecting trace quantities of asbestos. Representative fibres or fibre bundles are then selected and mounted for PLM examination.

Describe layered samples by their appearance, and note each distinct layer as a separate entity. Regulations in some jurisdictions require that distinct layers be analysed and reported separately. Other types of inhomogeneous sample will require detailed visual examination of all the different phases observed.

Asbestos is generally recognized by the fineness of its fibres, which are most often present as closely packed bundles of fibrils that will divide along their length when pressure is exerted on them with a probe or tweezers. An analyst will rapidly become familiar with characteristics such as distinctive surface lustre, flexibility, and tensile strength. Initial tentative identification of suspected asbestos fibres at this stage will be confirmed or refuted by subsequent examination using PLM, SEM or TEM.

7.2.3.5 Preparation of samples for PLM examination

A tentative identification based on the stereomicroscope evaluation is used to select the most appropriate RI mounting liquid. Fibres selected shall be dry and relatively free from other particulate matter. Representative fibres or fibre bundles are chosen and are placed on a clean microscope slide into a drop of RI liquid, and a clean cover glass is lowered gently onto the slide, avoiding trapping of air bubbles. The RI of the liquid selected should be 1,550 for suspected chrysotile, 1,680 for suspected amosite, 1,700 for suspected crocidolite, 1,605 for suspected tremolite or anthophyllite, and 1,630 for suspected actinolite or richterite/winchite.

If no fibres have been seen in the bulk sample using the stereomicroscope, or no asbestos fibres have been identified by PLM, then tweezers or probes should be used to take random test portions, after the laboratory sample has undergone suitable treatment (if necessary). At least two microscope slide preparations should be made with appropriate RI liquids for examination by PLM. Any large agglomerates should be teased apart with tweezers or needles, or sheared gently between two microscope slides, to give an even distribution of particles. Selection of large particles or fibre bundles may cause tilting of the cover slip and should be avoided. The amount of sample distributed should be such that the appearance and properties of individual fibres are not obscured by other particles.

7.2.3.6 Identification of asbestos by PLM and dispersion staining

Identification of a single asbestos fibre requires the observation of the following properties in the stated observation modes:

- a) morphology — observed in all illumination conditions;
- b) colour and pleochroism — observed in plane polarized light;
- c) birefringence — observed with crossed polars;
- d) extinction characteristics — observed with crossed polars;

NOTE The extinction characteristics can also be observed with crossed polars and a 530 nm retardation plate inserted. Under these conditions, when the interference colour of the fibre matches the background colour, the fibre is at the extinction position.

- e) sign of elongation — observed with crossed polars and a 530 nm retardation plate inserted;
- f) refractive indices — assessed using a dispersion staining objective with polarizer only inserted.

ISO 22262-1:2012(E)

The above order of observations facilitates the assessment of the morphological and optical properties in a logical sequence. Adjust the microscope to give Köhler illumination, centre the stage, and insert the polarizer (usually adjusted to the east–west orientation below the condenser). Under these conditions, observe the morphology and colour of the selected fibre. Rotate the stage and observe whether the fibres are pleochroic. Insert the analyser to give crossed polars, and rotate the stage to observe birefringence and whether the extinction angle is parallel to the length of the fibre or oblique. With the polars still crossed, insert the 530 nm retardation plate and rotate the stage to determine the sign of elongation. Finally, examine the fibre under dispersion staining conditions to assess the refractive indices for parallel and normal vibration directions. This may be achieved by observing the dispersion colours at the interface between the fibre and the RI liquid. Withdraw the analyser and the 530 nm retardation plate, increase the illumination, and insert a dispersion staining objective with a central stop in the back focal plane. Adjust the condenser aperture until the field of view becomes dark. View the back focal plane of the objective using either a Bertrand lens or a telescope ocular, and adjust the condenser alignment until the central beam is obscured by the central stop of the lens.

For fibres that exhibit parallel extinction, record the dispersion staining colours with the fibre parallel to the polarizer vibration direction and normal to the polarizer direction. If fibres exhibit oblique extinction, it is necessary to search for fibres that exhibit the maximum extinction angle. This can be achieved either by scanning the slide for such a fibre or by rotating fibres about their axes by touching the top of the cover slip with a needle. It is only in this orientation that a monoclinic fibre exhibits the γ and the α refractive indices. When such a fibre has been located, record the dispersion staining colours with the fibre at both extinction positions.

In practice, any other sequence may be used provided that all of the required properties are observed. For example, if it is difficult to locate any suspected asbestos fibres on the prepared mount because the sample is dominated by non-asbestos fibres, or if a random sample is being searched, the sample should be scanned with the microscope in the crossed polars condition to detect the asbestos fibres. The sign of elongation may also be observed by interpretation of the observed dispersion staining colours.

The observations made of the morphology and the optical properties of the fibre are recorded. Identification is based on comparing the recorded observations on the fibres selected for analysis (and mounted in the appropriate RI liquid) against the properties of asbestos reference standards. The compositions and optical properties of commercial chrysotile, amosite and crocidolite do not vary significantly, and therefore a close match between the optical properties of the sample fibre and the asbestos standard is normally achieved. Further representative fibres will need to be examined if the observations are inconclusive, or if more than one type of fibre was found in the stereomicroscopic or PLM analysis. For tremolite, actinolite and anthophyllite, the iron mass fraction can vary significantly from one source to another; higher iron mass fractions result in higher refractive indices. Examples of this variability can be seen by comparing the tremolite, actinolite and anthophyllite samples from the SRM 1867 and HSE sets of reference standards, as illustrated in Annex D.

7.2.3.7 Identification of asbestos**7.2.3.7.1 Morphology**

A detailed description for the morphology that is characteristic of asbestos is as follows. This morphology is characteristic of the larger fibres seen in stereomicroscope examinations and of fibres selected from laboratory samples for PLM identification of fibre type.

In the light microscope, the asbestiform habit is generally recognized by the following characteristics:

- a) the presence of fibre aspect ratios in the range of 20:1 or higher for fibres longer than 5 μm ;
- b) the capability of longitudinal splitting into very thin fibrils, generally less than 0,5 μm in width;
- c) in addition, observation of any of the following characteristics for the fibre type under consideration provides additional confirmation that the fibres are asbestiform:
 - 1) parallel fibres occurring in bundles,
 - 2) fibre bundles displaying splayed ends,
 - 3) fibres in the form of thin needles,

- 4) matted masses of individual fibres,
- 5) fibres showing curvature.

In practice, if chrysotile, crocidolite or amosite is identified in a commercial product, the assumption can safely be made that the fibres are asbestiform and that these fibres conform to the description above. This assumption can be made because these three types of asbestos were mined and processed to yield fibres with specific properties for intentional incorporation into products. Some anthophyllite asbestos was used in a few commercial products, but very little was mined and used commercially. Tremolite asbestos has been found in some surfacing and fireproofing applications in Japan. However, other than these occurrences, the amphiboles tremolite, actinolite, and richterite/winchite were not generally used in commerce, and their presence in a product is more likely a consequence of naturally occurring contamination of one or more of the major constituents. Accordingly, no assumption can be made as to whether the amphibole is asbestiform or non-asbestiform. Anthophyllite can occur as contamination of other mineral products, and in such situations no assumption can be made as to whether it is asbestiform or non-asbestiform. In some samples, these amphiboles may exhibit a mixture of morphological types, and quantitative determination of the regulatory status of such samples may require a detailed study of the fibre size distribution that is beyond the scope of this part of ISO 22262.

In general, for this part of ISO 22262, the presence of either the asbestiform or the non-asbestiform analogues of tremolite, actinolite, anthophyllite or richterite/winchite can usually be specified. If the majority of the amphibole fibres longer than 5 µm have aspect ratios equal to or lower than 5:1, and if the fibres do not exhibit any of the characteristics in c), it can be concluded that the amphibole is probably non-asbestiform, with the degree of certainty increasing with decreasing maximum aspect ratio. If any amphibole fibres longer than 5 µm with aspect ratios in the range of 20:1 or higher are observed, then it can be concluded that amphibole asbestos is probably present, with the degree of certainty increasing with increasing aspect ratio.

NOTE This is intended as guidance for analysts to discriminate between non-asbestiform and asbestiform amphibole populations. It is not intended to override the definition of asbestos as presented in 2.9 nor to override any national regulation.

It is necessary to appreciate that some samples may still present ambiguities with respect to discrimination between asbestiform and non-asbestiform analogues, and such ambiguities, when observed, shall be reported as part of the results.

7.2.3.7.2 Colour and pleochroism

Colour and pleochroism are observed using plane polarized light. Pleochroism is a diagnostic property in the identification of crocidolite. Crocidolite has a strong absorption, which gives a dark blue colour when the fibres are parallel to the polarizer vibration direction, changing to pale blue or grey when the fibres are perpendicular to the polarizer vibration direction. This is illustrated in Figures D.13 and D.14. Pleochroism in amosite may occur after heating, or occasionally in unheated fibres, depending on the Fe/Mg mass fraction ratio of the mineral. Chrysotile shows little colour contrast and no pleochroism in plane polarized light. Depending on the iron mass fraction, actinolite may exhibit a green colour when the fibres are parallel to the polarizer vibration direction, changing to a grey or yellowish colour when the fibres are perpendicular to the polarizer direction. Pleochroism in the HSE actinolite reference sample is illustrated in Figures D.43 and D.44.

7.2.3.7.3 Birefringence

When a particle with more than one RI is observed between crossed polars with its planes of vibration at 45° to those of the polarizer, interference colours are observed against the dark background. For asbestos, these interference colours depend on the fibre thickness, the birefringence and on the degree of randomness of the fibril orientation about the fibre axis.

Between crossed polars, an asbestos fibre aligned at 45° to the polarizer vibration direction should be clearly visible. Chrysotile has a low birefringence and gives a grey colour for thin fibres, and a white colour or higher first (or even second) order colours for thick fibres. Crocidolite has a low birefringence and anomalous interference colours caused by strong absorption in the visible light range. Amosite has moderate birefringence, giving white interference colours for thin fibres and higher first or second order colours for thick fibres. Tremolite, actinolite and anthophyllite, and richterite/winchite similarly exhibit moderate birefringence. Fibres with a variable thickness, e.g. with wedge-shaped cross-sections, show parallel bands of colour along their lengths, representing lower interference colours for progressively thinner sections. Examples are shown in Annex D.

ISO 22262-1:2012(E)

Isotropic materials have zero birefringence, and therefore do not exhibit interference colours. Between crossed polars, isotropic materials such as man-made vitreous fibres are almost invisible, but, depending on the difference between their RI and that of the immersion liquid, are often seen easily with the 530 nm retardation plate in position or with slightly uncrossed polars. Interference colours can be used to distinguish asbestos from some natural organic fibres, which may show non-uniform interference along the fibre length and also incomplete extinction.

7.2.3.7.4 Extinction angle

As the microscope stage is rotated through 360°, an asbestos fibre viewed between crossed polars disappears from view or “extinguishes” at four positions, each 90° apart, while at an angle of 45° to an extinction position, interference colours should be visible. Many fibres, including asbestos, generally show complete extinction when parallel to the vibration directions of the polarizer or the analyser. Chrysotile, amosite, crocidolite and anthophyllite each show parallel extinction when the fibre is parallel to the vibration direction of the polarizer or analyser. Tremolite, actinolite, and richterite/winchite may exhibit parallel extinction or oblique extinction, depending on the orientation of the fibre and the crystalline nature of the fibre. Highly asbestiform fibres of these amphiboles may show parallel extinction at all axial orientations. Other fibres of high aspect ratio may show oblique extinction, and axial rotation of the fibre by touching the cover glass of the slide with a needle allows the maximum extinction angle to be determined. Tremolite and some low-iron actinolite fibres that exhibit only parallel extinction cannot easily be discriminated from anthophyllite. However, it is unlikely that *all* of the tremolite or actinolite fibres in a sample would exhibit parallel extinction, and observation of some with oblique extinction angles would confirm the identity of the mineral, with the presumption that parallel extinction fibres with otherwise similar properties are the same mineral species. In these cases, reliable discrimination between anthophyllite and either tremolite or actinolite may only be possible by examination of the compositions of the fibres by SEM or TEM.

7.2.3.7.5 Sign of elongation

The sign of elongation describes the relationship between the length of the fibre and the optical properties. For asbestos fibres the two available vibration directions are parallel to the long axis and perpendicular to it. If the high RI vibration direction is parallel to the long axis, then the fibre is described as positive; if the low RI vibration direction is parallel to the long axis, the fibre is described as negative. Between crossed polars, with the 530 nm retardation plate inserted at 45° to the polarizer and analyser vibration directions, the sign of elongation can be determined by observing the colours of fibres that previously had given grey or white first order interference colours between crossed polars. For a retardation plate with the slow direction (usually marked) in the northeast–southwest direction, the first order colours observed are as follows:

Positive fibre	blue–green with fibre northeast–southwest
	orange–yellow with fibre northwest–southeast
Negative fibre	orange–yellow with fibre northeast–southwest
	blue–green with fibre northwest–southeast

Crocidolite is the *only* asbestos type that has a negative sign of elongation. However, exposure to temperatures of about 300 °C or higher may result in a reversal of the sign of elongation of crocidolite to positive. In such cases, however, the thermal history of the fibre is usually indicated by a change of colour.

7.2.3.7.6 Refractive indices

The refractive indices of an asbestos fibre are assessed by mounting a clean separated fibre in a liquid of known RI and orienting it either parallel or perpendicular to the polarizer vibration direction. One or more observations are conducted to determine whether the RI of the fibre is higher than, lower than or equal to that of the immersion liquid.

NOTE Classical mineralogical methods (References [16]–[18]) can be used for determination of refractive indices, but use of these methods requires access to a more extensive range of RI liquids than is specified in this part of ISO 22262, and it is also necessary to prepare multiple slide mounts in order to measure the γ and α indices for asbestos fibres.

Remove all filters from the light path except the daylight colour correction filter and the polarizer. Use the central stop dispersion staining objective to view fibres mounted in a liquid with an RI close to that of the fibre, so that dispersion staining colours can be observed. When dealing with an unknown sample, the observations a) to e) listed in the following can be used to help choose a suitable RI liquid such that the RI of the fibre and the liquid are sufficiently close that dispersion staining colours are produced.

Differences in dispersion between particles and liquids mean that, even though the refractive indices match at one wavelength, they may be quite different at others. This leads to colour effects at the particle/liquid interface when fibres are observed in matching RI liquids using white light. In practice, it is easiest to observe small bright particles and colours against a black background; these conditions are achieved with a central stop in the back focal plane of the objective when used with an axial beam of light produced by the condenser iris. The colours observed at the particle/liquid interface depend on the precise wavelength at which the RI of the liquid and that of the fibres match. When the match of RI is at a wavelength of 589,3 nm (the D line of sodium), the colour at the particle/liquid interface is a deep blue–magenta. For central stop dispersion staining, the colour observed indicates how close, and in which direction, the RI of the particle differs from that of the immersion medium:

a)	Fibre refractive index	>>	Liquid refractive index:	White
b)	Fibre refractive index	>	Liquid refractive index:	Purple–red/orange/yellow
c)	Fibre refractive index	=	Liquid refractive index:	Deep blue–magenta
d)	Fibre refractive index	<	Liquid refractive index:	Blue/blue–green
e)	Fibre refractive index	<<	Liquid refractive index:	White

Different colours are observed when the fibre is oriented parallel or perpendicular to the polarizer vibration direction, arising from the different refractive indices of asbestos fibres in the two perpendicular directions relative to the polarizer vibration direction. A recording of the predominant colours is used to characterize the refractive indices of the fibres. Identification of chrysotile, amosite and crocidolite can be performed with a dispersion staining objective using three high dispersion liquids having the RI values 1,550 for chrysotile, 1,680 for amosite, and 1,700 for crocidolite. In practice, for commercial chrysotile, because of variations in the fibre composition according to the source, a small range of fibre refractive indices and dispersion staining colours may be encountered. The refractive indices of commercial amosite and crocidolite do not vary significantly. For the purpose of this part of ISO 22262, the three RI liquids adequately cover the observed range of refractive indices for chrysotile, amosite, and crocidolite from all known major commercial sources. Crocidolite from Bolivia is an exception in that the refractive indices are lower than those from other sources of crocidolite. However, Bolivian crocidolite is very rare in commerce. Should Bolivian crocidolite be encountered, it can be readily recognized on the basis of its fibrous morphology, negative sign of elongation, and blue–grey pleochroism.

Identification of tremolite, actinolite and anthophyllite can often be performed using a dispersion staining objective using liquids of RI values 1,605 and 1,630. Tremolite or actinolite should be suspected if some of the fibres exhibit oblique extinction, and the γ index observed parallel to the extinction position can be used to define whether the fibre is tremolite or actinolite. If it is important to discriminate between tremolite and actinolite, classify fibres as tremolite if the γ index is estimated to be equal to or lower than 1,637 and as actinolite if the γ index is estimated to be higher than 1,637.

Some sources of talc contain fibres that can be mistaken for anthophyllite. These fibres have intergrowths of both the anthophyllite and talc crystal structures. The fibres exhibit refractive indices that are lower than those of anthophyllite and intermediate between those of talc and anthophyllite. If this type of fibre is present, examine the sample in a liquid of RI 1,615. If no γ indices are observed that are higher than 1,615, classify the fibres as talc. Classify any fibres with γ indices equal to or exceeding 1,615 as anthophyllite.

Identification of richterite/winchite asbestos is difficult by PLM alone. Richterite/winchite should be suspected if the sample also contains vermiculite or talc. Attempts to identify richterite/winchite by PLM alone usually result in classification of the fibres as actinolite, and such an error may be important for regulatory interpretation. Where richterite/winchite is suspected, and the fibres exhibit properties similar to those of actinolite, it is recommended that the fibres be identified by either SEM or TEM.

Annex C shows dispersion staining charts for the α and γ refractive indices of chrysotile, amosite, crocidolite, tremolite, actinolite, anthophyllite, and richterite/winchite in the appropriate RI liquids. Chrysotile exhibits a

ISO 22262-1:2012(E)

small range of refractive indices, depending on the source. For each of the types of asbestos, an acceptable range of colour for the α and γ dispersion staining colours is indicated, representing the observed range in minerals from commercial sources. For chrysotile, it is also important to establish that the λ_{α} values for the parallel and normal orientations with respect to the polarizer vibration direction do not differ by more than 100 nm in recognition of its low birefringence. For chrysotile, although there is a range of refractive indices depending on the source, studies have shown that the two indices vary in an approximately parallel manner.

Figures D.1 and D.2 show an example of chrysotile, mounted in 1,550 RI liquid, viewed between crossed polars with the 530 nm retardation plate inserted. Note the fibrillar, wavy appearance, and the blue–green colour in the northeast direction, changing to an orange colour when the fibres are rotated into the northwest direction, showing that the fibres have a positive sign of elongation. Figures D.3 and D.4 show an example of chrysotile viewed under dispersion staining conditions, showing magenta for fibres parallel to the vibration direction of the polarizer and blue for fibres normal to the vibration direction of the polarizer. However, it is necessary to consider that the colours exhibited in the two directions vary depending on the source of the chrysotile and any prior heating or acid treatment. Nevertheless, any variation applies to both the α and γ refractive indices, and the difference between the two (birefringence) remains nearly constant regardless of the source of the chrysotile.

Figures D.5 and D.6 show an example of amosite, mounted in 1,680 RI liquid, viewed between crossed polars with the 530 nm retardation plate inserted. The thin fibres exhibit a blue–green colour in the northeast direction, changing to an orange colour when the fibres are rotated into the northwest direction, showing that the fibres have a positive sign of elongation. Because of the higher birefringence of amosite, some of the thicker fibres exhibit first and second order interference colours that can be compared with the interference colour chart in Annex B. Figures D.7 and D.8 show amosite viewed under dispersion staining conditions, with a gold colour for fibres parallel to the vibration direction of the polarizer and blue for fibres normal to the vibration direction of the polarizer. Except for heated amosite, these colours vary only slightly for amosite from different sources. The behaviour of heated amosite for the two fibre orientations is illustrated in Figures D.9 and D.10. Heated amosite exhibits significantly higher refractive indices, and dark brown–light brown pleochroism for fibres parallel and normal to the polarizer vibration directions, respectively.

Figures D.11 and D.12 show an example of crocidolite, mounted in 1,700 RI liquid, viewed between crossed polars with the 530 nm retardation plate inserted. The fibres exhibit a yellow–orange colour in the northeast direction, changing to a blue colour when the fibres are rotated into the northwest direction, showing that the fibres have a negative sign of elongation. The birefringence of crocidolite is very low, so the dispersion staining colours for fibres parallel and normal to the polarizer vibration direction are not very different. However, a lighter blue is discernable for the parallel direction, indicating that the lower RI is parallel to the length of the fibre (Figures D.13 and D.14). The blue–grey pleochroism of crocidolite is shown in Figures D.15 and D.16. The behaviour of heated crocidolite for the two fibre orientations is illustrated in Figures D.17 and D.18. Heated crocidolite exhibits dark brown–light brown pleochroism for fibres parallel and normal to the polarizer vibration directions, respectively. For heated crocidolite such as that illustrated, the sign of elongation is positive, and in this condition electron microscopy with energy dispersive X-ray analysis is necessary to discriminate between crocidolite and amosite.

Figures D.19 and D.20 show an example of SRM 1867 tremolite, mounted in 1,605 RI liquid, viewed between crossed polars with the 530 nm retardation plate inserted. The thin fibres exhibit a blue–green colour in the northeast direction, changing to an orange colour when the fibres are rotated into the northwest direction, showing that the fibres have a positive sign of elongation. Because of the moderate birefringence of tremolite, some of the thicker fibres can exhibit first and second order interference colours that can be compared with the interference colour chart in Annex B. Figures D.21 and D.22 show SRM 1867 tremolite viewed under dispersion staining conditions, with a yellow colour for fibres parallel to the extinction position closest to the vibration direction of the polarizer and dark blue for fibres at the other extinction position. The dark blue colour of the fibre in Figure D.22 and the magnitude of the extinction angle indicate that this fibre presents the α RI at this orientation. Figures D.23 to D.26 show SRM 1867 tremolite mounted in 1,625 RI liquid, which is intermediate between the γ and α indices of the fibres. Figures D.27 to D.30 show an example of HSE reference tremolite, mounted in 1,605 RI liquid. This variety of tremolite exhibits parallel extinction.

Figures D.27 and D.28 show an example of SRM 1867 actinolite, mounted in 1,630 RI Index liquid, viewed between crossed polars with the 530 nm retardation plate inserted. The thin fibres exhibit a blue–green colour in the northeast direction, changing to an orange colour when the fibres are rotated into the northwest direction, showing that the fibres have a positive sign of elongation. Because of the moderate birefringence of tremolite, some of the thicker fibres can exhibit first and second order interference colours that can be compared with the

interference colour chart in Annex B. Figures D.29 and D.30 show SRM 1867 tremolite viewed under dispersion staining conditions, with a purple–red colour for fibres parallel to the extinction position closest to the vibration direction of the polarizer and light blue for fibres at the other extinction position. Figures D.39 to D.44 show an example of HSE reference actinolite mounted in 1,640 RI liquid. The HSE actinolite is considerably more asbestiform than the SRM 1867 actinolite, and exhibits parallel extinction as well as pleochroism as illustrated in Figures D.43 and D.44.

Figures D.31 and D.32 show an example of SRM 1867 anthophyllite, mounted in 1,605 RI liquid, viewed between crossed polars with the 530 nm retardation plate inserted. The thin fibres exhibit a blue–green colour in the northeast direction, changing to an orange colour when the fibres are rotated into the northwest direction, showing that the fibres have a positive sign of elongation. Because of the moderate birefringence of anthophyllite, some of the thicker fibres can exhibit first and second order interference colours that can be compared with the interference colour chart in Annex B. Figures D.33 and D.34 show anthophyllite viewed under dispersion staining conditions, with blue–purple colours for fibres parallel to the vibration direction of the polarizer and light blue for fibres normal to the vibration direction of the polarizer. Figure D.33 shows some fibres that exhibit purple dispersion staining colours. This indicates that the RI in that orientation is higher than 1,630, representing the γ index. Other fibres exhibit a blue colour, which indicates that the RI in the particular axial orientation is lower than 1,630. This is probably a result of intergrowths of talc in the fibre bundle, since all fibres in this orientation relative to the polarizer direction should exhibit only the γ index. Figures D.45 to D.48 show an example of HSE reference anthophyllite in 1,605 RI liquid.

Figures D.49 and D.50 show an example of richterite/winchite, mounted in 1,630 RI liquid, viewed between crossed polars with the 530 nm retardation plate inserted. The thin fibres exhibit a blue–green colour in the northeast direction, changing to an orange colour when the fibres are rotated into the northwest direction, showing that the fibres have a positive sign of elongation. Because of the moderate birefringence, some of the thicker fibres exhibit first and second order interference colours that can be compared with the interference colour chart in Annex B. Figures D.51 and D.52 show richterite/winchite viewed under dispersion staining conditions, with a purple colour for fibres parallel to the extinction position closest to the vibration direction of the polarizer and blue for fibres at the other extinction position. Regardless of the highly asbestiform appearance of this sample, the fibres exhibit oblique extinction.

7.2.4 Interferences

7.2.4.1 Heated asbestos

Changes occur to asbestos when it is heated. Therefore, care should be taken if sample preparation involves heating the asbestos-containing material. Even short exposure of crocidolite to temperatures of 300 °C to 500 °C may cause colour changes, and increases in both RI and the birefringence. For crocidolite, the changes with heating are: the sign of elongation reverses and the colour changes from grey to yellow then orange–brown; pleochroism is suppressed at the grey coloration stage, but reappears on further heating. For amosite, the sign of elongation remains positive, but the colour changes from yellow to a dark brown, and pleochroism is observed. Thus, heat-degraded crocidolite and amosite cannot be distinguished from each other by light microscopy after exposure to temperatures above about 500 °C. The refractive indices of chrysotile increase after significant exposure to temperatures of about 600 °C or greater; the birefringence decreases and, in a few cases, the sign of elongation changes to negative and the fibres become pale brown. The alteration of asbestos by heat is dependent on both the duration and the temperature of exposure. Prolonged exposure to high temperatures can result in complete degradation, but, with judicious sampling, unaffected fibres can often be detected in peripheral locations or in debris that became detached during installation. However, in extreme situations, analytical electron microscopy may be required to aid identification. Examples of heated amosite and crocidolite in plane polarized light are shown in Annex D.

7.2.4.2 Leached chrysotile

Exposure of chrysotile to acidic aqueous media may result in reduction of the refractive indices as a consequence of leaching of magnesium from the crystal structure. Progressive leaching also results in reduction of the birefringence, and ultimately the fibre becomes isotropic. In addition to the action of mineral acids used in some of the procedures in this part of ISO 22262, leaching may also occur in chrysotile exposed to aggressive water (water with only low mass fractions of dissolved calcium and magnesium, and with low pH values). Leached

ISO 22262-1:2012(E)

chrysotile may be encountered on the surfaces of chrysotile cement products such as roofing materials after long periods of exposure to rain.

7.2.4.3 Fibres with morphological and/or optical properties similar to those of asbestos

Most of the fibres discussed in the following paragraphs occur infrequently in samples presented for analysis. However, analysts need to be aware of their existence and distinguishing characteristics in PLM. There are five types of fibre that can resemble chrysotile. Some mineral fibres can also superficially resemble amphiboles.

Polyethylene is the most important of the interfering fibres because it is used as an asbestos substitute. Shredded polyethylene resembles chrysotile. In 1,550 RI liquid, the dispersion staining colours are within the range for those of chrysotile, although experienced analysts will observe morphological differences and desaturation of the blue colour perpendicular to the fibres because of the low RI in this direction. The birefringence is also higher than that of chrysotile. If polyethylene is suspected, the melting of fibres on a hot plate or in a flame will readily distinguish them from chrysotile.

Fibres from leather have low birefringence and similar dispersion staining colours to chrysotile. At magnifications below 100 times, they appear to have similar morphology to that of chrysotile, but they usually exhibit clearly visible uniform fibrils. Individual chrysotile fibrils are too small to be seen by PLM, although uniform bundles of fibrils are visible. In most instances, the differences between chrysotile and leather can be detected during stereomicroscope examination. If leather is suspected to be present, the sample may be ashed at 400 °C to remove it, and then the residual ash can be reexamined for identification of asbestos. Care should be taken not to allow the sample temperature to rise above 500 °C.

Macerated aramid fibres may appear to have a morphology similar to that of chrysotile, but these fibres can be recognized by their extremely high birefringence showing high-order white interference colours. When mounted in 1,550 RI liquid, the refractive indices are clearly inconsistent with those of chrysotile.

Spider web and natural organic fibres such as cellulose and feathers have refractive indices close to those of chrysotile and show similar interference colours between crossed polars. In a sample with little non-fibrous material, the morphology of these fibres can be readily distinguished from that of chrysotile. However, in samples containing significant particulate material, sometimes only a small portion of the fibre can be observed due to obscuration by the particles and this can lead to misidentification. These fibres can be removed by ashing the sample or exposing individual fibres to a flame.

Talc fibres are thin ribbons that may sometimes be recognized by characteristic morphological twists. For the RI parallel to the fibre length, they have a value in the range 1,589 to 1,600, resulting in a pale yellow dispersion staining colour when immersed in 1,550 RI liquid. The other two refractive indices of talc are in the ranges 1,539 to 1,550 and 1,589 to 1,600, and with a dispersion staining objective, blue and pale yellow colours perpendicular to the fibre are observed in 1,550 RI liquid at different orientations as the fibre is "rolled". It is important to demonstrate that the γ -index of any straight fibres that do not exhibit ribbon-like morphology is lower than 1,615, in order to exclude the possibility that the fibres are anthophyllite.

Fibrous brucite normally consists of straight white to pale brown fibres, but brucite lacks the tensile strength of asbestos. It is brittle and is soluble in acid. Brucite has a negative sign of elongation, which reverses to positive when heated. Sometimes brucite fibres may appear to be isotropic. It is distinguished from chrysotile by its refractive indices. In central stop dispersion staining, brucite yields colours of yellow to pale yellow in 1,550 RI liquid.

Superficially, fibrous wollastonite can be mistaken for tremolite. Fibrous wollastonite has an acicular morphology, is very brittle, white in appearance, and is slowly soluble in acid. After treatment for a short time (e.g. 15 min) in 100 g/l hydrochloric acid, the fibres exhibit etched areas. Wollastonite always displays a non-zero extinction angle. The RI almost parallel to the fibre is in the range 1,628 to 1,650. The other two refractive indices are in the ranges 1,626 to 1,640, and 1,631 to 1,653, and are observed across the fibre, at different orientations as the fibre is rolled. A distinctive feature is that the RI with the length of the fibre almost parallel to the polarizer vibration direction is intermediate between the two refractive indices observed at the different orientations across the fibre as the fibre is rolled. Examination of many fibres with crossed polars and with the 530 nm retardation plate inserted shows most as having a positive sign of elongation, and fibres in other orientations appear to have a negative sign of elongation. Gentle pressure on the cover slip with a needle can be used to rotate a fibre and show it to change from a positive to a negative sign of elongation as it is rolled into a different axial orientation.

Diatomaceous earth may exhibit acicular fragments with the appearance of fibres. However, these fibres have a low RI of approximately 1,42 and are readily distinguished from asbestos fibres using dispersion staining. Also, there is usually characteristic morphology that can be recognized when the material is examined at magnifications around 500 times.

7.2.4.4 Identification of other sample components

A laboratory conducting routine analysis selectively removes fibres for examination and ignores the majority of the non-asbestos materials. The composition of many asbestos products is relatively uniform during the manufacture and a wider knowledge of these non-asbestos materials can be helpful in recognizing many common products or formulations. Because of this, the analyst should become familiar with the information in Annex A.

8 Analysis by SEM

8.1 General

Complete details relating to identification of mineral fibres, including asbestos fibres, using SEM are given in ISO 14966.^[7]

8.2 Requirements

8.2.1 Scanning electron microscope, with an accelerating voltage of at least 20 kV.

8.2.2 Energy dispersive X-ray system. The SEM shall be equipped with an energy dispersive X-ray analyser capable of achieving a resolution better than 170 eV (FWHM) on the Mn K_{α} peak. The performance of an individual combination of SEM and solid-state X-ray detector is dependent on a number of geometrical factors. The X-ray detector shall be capable of detecting sodium in crocidolite, in order to permit discrimination between crocidolite and amosite.

8.2.3 Vacuum coating unit, capable of producing a vacuum better than 0,013 Pa. It shall be used for vacuum deposition of carbon on the SEM specimens. A sample holder is required which allows the SEM specimens to be continuously rotated and tilted during the coating procedure.

8.3 Calibration

For the purposes of this method, calibration consists of obtaining EDXA spectra from reference samples of chrysotile, amosite, crocidolite, tremolite, actinolite, anthophyllite, and richterite/winchite. The chemical compositions of commercial chrysotile, amosite, crocidolite and anthophyllite do not vary substantially, and comparison of unknown EDXA spectra with those from the three reference asbestos samples constitutes sufficient identification for this part of ISO 22262. For most purposes, it is not necessary to discriminate between tremolite and actinolite, since the compositional boundary between them is a matter of convention. When it is necessary to discriminate between tremolite and actinolite, the SRM 1867 tremolite and actinolite samples are particularly useful, since these samples have compositions just below and just above the boundary defined by the International Mineralogical Association. In some applications, the magnesium may be partially leached from chrysotile, leading to a chemical composition that approaches that of talc. In order to facilitate the discrimination between chrysotile and talc or anthophyllite, it is recommended that an EDXA spectrum also be obtained from a known sample of talc. Use this spectrum to define the upper limit of the magnesium mass fraction in talc. Examples of EDXA spectra obtained on the SRM 1866 and SRM 1867 samples, the HSE reference asbestos samples, Bolivian crocidolite and richterite/winchite are illustrated in Annex E. For positive identification, reference EDXA spectra from asbestos standards similar to those shown in Annex E should be recorded using the specific combination of SEM and EDXA detector, since the geometries and detector efficiencies vary between different instruments.

ISO 22262-1:2012(E)

8.4 Sample preparation

Select representative fibres, either from the original laboratory sample or from the residue remaining after treatment according to the procedures specified in 7.2.2 and 7.2.3. Mount these fibres either directly on a graphite SEM stub or on double-sided adhesive tape on an SEM stub. Place the SEM stub in the vacuum coating unit and evaporate a thin film of carbon on to the surface of the fibres.

8.5 Qualitative analysis by SEM

8.5.1 Acquisition of EDXA spectra

It is important to obtain the EDXA spectrum from clean areas of the fibre, since distortion of peak heights by contributions from attached particles may compromise the identification. Particles adjacent to the fibre under analysis may also contribute to the EDXA spectrum, and this effect should be minimized to the extent possible.

8.5.2 Sample analysis

The SEM stub with the unknown fibres is examined at a low magnification in the SEM, and EDXA spectra are acquired from regions of the fibres that are clear of other attached particles. The EDXA spectra are compared with the reference spectra.

8.5.2.1 Chrysotile

Classify a fibre as chrysotile if:

- a) the Mg and Si peaks are clear, and comparable in Mg/Si peak height ratio with that of the reference;
- b) any Fe, Mn and Al peaks are small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

IMPORTANT — Anthophyllite and talc both yield EDXA spectra that conform to these specifications, but the Mg/Si peak height ratio for these minerals is lower than that for chrysotile. In order to avoid erroneous classification of talc or anthophyllite as chrysotile, take account of the Mg/Si peak height ratio and calibrate the EDXA detector using known samples of chrysotile and talc.

8.5.2.2 Amosite

Classify a fibre as amosite if:

- a) the Mg, Si and Fe peaks are comparable in ratio to those of the reference amosite;
- b) no statistically significant peaks from Na or Al are present;
- c) the Mn peak, if present, is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

8.5.2.3 Crocidolite

Classify a fibre as crocidolite if:

- a) the Na, Si and Fe peaks are comparable in ratio with those of the reference crocidolite;
- b) any peak from Mg is small, and no peaks from Al or Mn are visible.

NOTE 1 Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

NOTE 2 If a large peak from Mg is present, it is possible that the fibre is magnesio-riebeckite. Bolivian crocidolite is the only known commercial source, although this variety of crocidolite can occur as contamination of other minerals.

8.5.2.4 Tremolite

Classify a fibre as tremolite if:

- a) the Mg, Si, Ca and Fe peaks are comparable in ratio to those of reference tremolite;
- b) no statistically significant peaks from Na or Al are present;
- c) the Mn peak, if present, is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

8.5.2.5 Actinolite

Classify a fibre as actinolite if:

- a) the Mg, Si and Fe peaks are comparable in ratio to those of the reference actinolite;
- b) no statistically significant peaks from Na or Al are present;
- c) the Mn peak, if present, is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

8.5.2.6 Anthophyllite

Classify a fibre as anthophyllite if:

- a) the fibre is straight and exhibits no evidence of a ribbon-like structure;
- b) the Mg and Si peaks are comparable in ratio to those of the reference anthophyllite — anthophyllite from some sources may not exhibit a peak from Fe, although in commercial anthophyllite a peak from Fe will probably be observed;
- c) no statistically significant peaks from Na or Al are present;
- d) the Mn peak, if present, is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

8.5.2.7 Sodic–calcic amphibole asbestos (richterite/winchite)

Classify a fibre as sodic–calcic amphibole if:

- a) the spectrum is similar to that of actinolite or tremolite, but the Ca peak is substantially smaller and an Na peak is present — a K peak may also be evident;
- b) no statistically significant peak from Al is present;
- c) the Mn peak, if present, is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

9 Analysis by transmission electron microscope

9.1 General

Full details relating to identification of asbestos fibres using TEM are given in ISO 10312^[2] and ISO 13794^[4]. Additional information on the investigation of minerals using TEM is given in References [26]–[29]. A simple technique for quantitative measurement of electron diffraction patterns is available (Reference [30]). Detailed interpretation of single-crystal electron diffraction patterns, sometimes required for definitive identification of amphibole fibres, can be accomplished using a computer program, e.g. XIDENT (Reference [31]).

ISO 22262-1:2012(E)

9.2 Requirements

9.2.1 Transmission electron microscope, operating at an accelerating potential of 80 kV to 120 kV. The TEM shall have an illumination and condenser lens system capable of forming an electron probe smaller than 250 nm in diameter.

9.2.2 Energy dispersive X-ray analyser. The TEM shall be equipped with an energy dispersive X-ray analyser capable of achieving a resolution better than 170 eV (FWHM) on the Mn K_{α} peak. Since the performance of individual combinations of TEM and EDXA equipment is dependent on a number of geometrical factors, the required performance of the combination of the TEM and X-ray analyser is specified in terms of the measured X-ray intensity obtained from a fibre of small diameter, using a known electron beam diameter. Solid-state X-ray detectors are least sensitive in the low-energy region, and so measurement of sodium in crocidolite is the primary performance criterion. The combination of electron microscope and X-ray analyser shall yield, under routine analytical conditions, a peak from sodium that allows discrimination between the spectra from crocidolite and amosite.

9.2.3 Vacuum coating unit. If carbon-coated specimen grids are not available, a vacuum coating unit capable of producing a vacuum better than 0,013 Pa shall be used for vacuum deposition of carbon for preparation of carbon-coated grids.

9.2.4 Calibration grids. TEM specimen grids prepared from dispersions of chrysotile, amosite, crocidolite, tremolite, actinolite, anthophyllite, richterite/winchite, and talc are required for calibration of the EDXA system. It is recommended that gold or nickel grids be used to facilitate detection of sodium. For calibration of the camera constant for interpretation of ED patterns, TEM specimen grids with vacuum-evaporated thin films of gold, aluminium or thallos [Ti(l)] chloride deposited on to carbon films are required.

9.2.5 Disposable tip micropipettes, suitable for transferring a volume of approximately 3 μ l to a carbon-coated TEM specimen grid.

9.3 Calibration

9.3.1 EDXA system

For the purposes of this method, calibration consists of obtaining EDXA spectra from reference samples of chrysotile, amosite, crocidolite, tremolite, actinolite, anthophyllite, and richterite/winchite. The chemical compositions of commercial chrysotile, amosite, crocidolite, and anthophyllite do not vary substantially, and comparison of unknown EDXA spectra with those from the three reference asbestos samples constitutes sufficient identification for this part 1 of ISO 22262. For most purposes, it is not necessary to discriminate between tremolite and actinolite, since the compositional boundary between them is a matter of convention. When it is necessary to discriminate between tremolite and actinolite, the SRM 1867 tremolite and actinolite samples are particularly useful since they have compositions just below and just above the boundary defined by the International Mineralogical Association (Reference [24]). In some applications, the magnesium may be partially leached from chrysotile, leading to a chemical composition that approaches that of talc. In order to facilitate the discrimination between chrysotile and talc or anthophyllite, it is recommended that an EDXA spectrum also be obtained from a known sample of talc. Use this spectrum to define the upper limit of the magnesium mass fraction in talc. Examples of EDXA spectra obtained on the SRM 1866 and SRM 1867 samples, the HSE reference asbestos samples, Bolivian crocidolite, and richterite/winchite appear in Annex F. For positive identification, reference EDXA spectra from asbestos standards similar to those shown in Annex F should be recorded using the specific combination of TEM and EDXA detector, since the geometries and detector efficiencies vary between different instruments.

9.3.2 Camera constant for interpretation of ED patterns

Use gold, aluminium or thallos [Ti(l)] chloride to calibrate the radius-based camera constant, λL , the product of the wavelength and camera length, for electron diffraction patterns. Specimen grids with a vacuum deposited, thin, polycrystalline film of one of these materials on a thin carbon film are used for the calibration. The calibration data for the first two diffraction rings, where D is the ring diameter, are shown in Table 6.

Table 6 — Radius-based camera constants

Calibration material	Radius-based camera constant λL	
	1st diffraction ring	2nd diffraction ring
Gold	0,117 74 <i>D</i>	0,101 97 <i>D</i>
Aluminium	0,116 90 <i>D</i>	0,101 24 <i>D</i>
Thallous [Tl(I)] chloride	0,192 14 <i>D</i>	0,135 86 <i>D</i>

9.4 Sample preparation

Remove representative fibres from the sample (see 7.2.2 and 7.2.3), and place them in an agate mortar, and pestle. Add approximately 1 ml of ethanol, and grind the fibres with the pestle until they are well dispersed in the ethanol. Set up a laboratory stand and clamp, and use it to hold a pair of fine-point tweezers that are supporting a carbon-coated TEM specimen grid, with the carbon side facing upwards. Using a disposable tip micropipette, drop a 3 μ l volume of the ethanol dispersion on to the grid, and allow it to dry. Drying is faster if the grid is held under a heat lamp. When dry, the TEM grid is ready for examination.

If crocidolite or sodic-calcic amphibole is suspected, use of a carbon-coated gold TEM grid is recommended in order to avoid partial overlap of the Na K_{α} peak by the Cu L_{α} X-ray peak if a copper grid is used.

9.5 Qualitative analysis by TEM

9.5.1 Acquisition of EDXA spectra

It is important to obtain the EDXA spectrum from clean areas of the fibre, since distortion of peak heights by contributions from attached particles may compromise the identification.

9.5.2 Chrysotile

The morphological structure of chrysotile as seen in the TEM is characteristic and, with experience, can be recognized readily. However, a few other minerals have a similar appearance, and morphological observation by itself is inadequate for most samples.

Classify a fibre as chrysotile if:

- a) the Mg and Si peaks are clear, and comparable in Mg/Si peak height ratio with that of reference chrysotile;
- b) any Fe, Mn and Al peaks are small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

IMPORTANT — Anthophyllite and talc both yield EDXA spectra that conform to these specifications, but the Mg/Si peak height ratio for these minerals is lower than that for chrysotile. In order to avoid erroneous classification of talc or anthophyllite as chrysotile, take account of the Mg/Si peak height ratio and calibrate the EDXA detector using known samples of chrysotile and talc.

9.5.3 Amosite

Classify a fibre as amosite if:

- a) the Mg, Si and Fe peaks are comparable in ratio to those of the reference amosite;
- b) no statistically significant peaks from Na or Al are present;
- c) the Mn peak, if present, is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

ISO 22262-1:2012(E)

9.5.4 Crocidolite

Classify a fibre as crocidolite if:

- a) the Na, Si and Fe peaks are comparable in ratio with those of the reference crocidolite;
- b) no statistically significant peak from Al is present;
- c) any peak from Mg is small, and no Mn peak is visible.

NOTE 1 Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

NOTE 2 If a large peak from Mg is present, it is possible that the fibre is magnesio-riebeckite. Bolivian crocidolite is the only known commercial source, although this variety of crocidolite can occur as contamination of other minerals.

9.5.5 Tremolite

Classify a fibre as tremolite if:

- a) the Mg, Ca and Fe peaks are comparable in ratio with those of the reference tremolite;
- b) no statistically significant peak from Al is present;
- c) any peak from either Na or K is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

9.5.6 Actinolite

Classify a fibre as actinolite if:

- a) the Mg, Si and Fe peaks are comparable in ratio to those of the reference actinolite;
- b) no statistically significant peaks from Na or Al are present;
- c) the Mn peak, if present, is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

9.5.7 Anthophyllite

Classify a fibre as anthophyllite if:

- a) the fibre is straight and exhibits no evidence of a ribbon-like structure;
- b) the Mg and Si peaks are comparable in ratio to those of reference anthophyllite — anthophyllite from some sources may not exhibit a peak from Fe, although in commercial anthophyllite a peak from Fe will probably be observed;
- c) no statistically significant peaks from Na or Al are present;
- d) the Mn peak, if present, is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

9.5.8 Sodic–calcic amphibole asbestos (richterite/winchite)

Classify a fibre as sodic–calcic amphibole if:

- a) the spectrum is similar to that of actinolite or tremolite, but the Ca peak is substantially smaller and an Na peak is present — a K peak may also be evident;
- b) no statistically significant peak from Al is present;

- c) the Mn peak, if present, is small.

NOTE Depending on the composition of any adjacent or attached particles, other peaks can also be visible.

10 Test report

The test report shall contain at least the following information:

- a) reference to this part of ISO 22262 (ISO 22262-1:2012);
- b) the identification of the sample, including the location (if known by the analyst);
- c) the date of the analysis;
- d) the identity of the analyst;
- e) all applicable specimen preparation details;
- f) any procedure used not specified in this part of ISO 22262 or regarded as an optional procedure;
- g) the variety or varieties of asbestos detected;
- h) the analytical method used to identify the asbestos.

Items i) to k) shall be recorded in the laboratory data, but the extent to which they are included as part of the test report is optional:

- i) the observations made to confirm the identification of the asbestos varieties reported, including any optional procedures;
- j) the estimated mass fraction(s) of the asbestos varieties detected in ranges as follows:
 - 1) none detected,
 - 2) detected,
 - 3) 0,1 % to 5 %,
 - 4) 5 % to 50 %,
 - 5) 50 % to 100 %;

NOTE 1 These categories for reporting asbestos mass fractions are estimates only; they are intended to provide guidance in the interpretation of results. If it is necessary to make critical decisions on the basis of results in the range from "non-detected" to 5 %, sample analysis by a quantitative method is appropriate (e.g. using ISO 22262-2).

NOTE 2 The reporting category "detected" provides the analyst with a means of reporting the result when only one or two fibres are detected in the analysis, the observation of which may be a consequence of unintended contamination of the sample.

- k) the variety or varieties of any non-asbestos fibres detected, and the observations made which allowed these fibres to be discriminated from asbestos fibres.

An example of a suitable format for the test report is shown in Annex H.

ISO 22262-1:2012(E)

Annex A

(normative)

Types of commercial asbestos-containing material

The properties of asbestos such as non-flammability, chemical stability, and high strength have led worldwide to a broad use of this mineral in the building and industrial sectors. Asbestos–cement products, asbestos-containing lightweight panels and fire-prevention panels, asbestos packings and asbestos cloths, asbestos boards, asbestos foams, asbestos-containing fireproofing and acoustic and decorative plasters (sprayed asbestos), and asbestos-containing compositions for trowel application and putties are the most important uses. In addition, there is also a variety of products to which asbestos fibres were frequently added at smaller mass fractions, e.g. paints for protective coatings, adhesives, plastic sheets, and tiles.

Table A.1 gives the most important asbestos-containing materials with examples of their applications and the typical asbestos mass fractions. In exceptional cases, asbestos mass fractions deviating from those quoted may have been used.

Table A.1 — Asbestos-containing materials; examples of use and typical asbestos content

Product	Examples of application	Typical asbestos type and mass fraction
Asbestos–cement flat boards	Roof claddings Sidings Banister elements Windowsills Staircases Partition walls Support for cable runs In small sizes as slates and shingles in the roofing and siding sectors	Chrysotile 10 %–12 %, Sometimes also <5 % crocidolite or amosite in addition to chrysotile
Asbestos–cement corrugated sheets	Roof claddings Perimeter insulation Sidings in the industrial sector	Chrysotile 10 %–12 %, sometimes also, with some manufacturers, <5 % crocidolite in addition to chrysotile
Asbestos–cement pipes or ducts	Drinking water and wastewater pipes Service pipes Inlet air and exhaust air ducts Cable shafts	Chrysotile 10 %–15 %. Drinking water pipe also <5 % crocidolite or amosite in addition to chrysotile
Asbestos–cement mouldings	Standard ashtrays Flower boxes Garden articles Sculptures	Chrysotile 10 %–12 %

ISO 22262-1:2012(E)

Table A.1 (continued)

Product	Examples of application	Typical asbestos type and mass fraction
Asbestos-containing lightweight building boards or fire-resistant panels	Sealing of openings in walls required to be fire resistant Fire-protection encasement of ventilation ducts, cable ducts and cable shafts Fire closures in walls required to be fire resistant (fire shutters, fire barriers) Fire-protection encasements Smoke-removal ducts Insert in fire-resistant doors and gates Substructure of luminaries (lighting fixtures)	Chrysotile ~15 % and amosite ~15 %
Asbestos-containing lightweight building boards or fire-resistant panels	Lining fire-hazard rooms Partition walls, partition surfaces, doors Sanitary modules Support and beam encasements Smoke aprons Fire locks	Chrysotile <50 %, sometimes amosite <35 %
Asbestos-containing pipe and boiler insulations	Corrugated paper pipe insulation 85 % magnesia block and pipe insulation Calcium silicate block and pipe insulation	Chrysotile 30 %–100 % Total of 15 % asbestos, can be chrysotile, amosite or crocidolite, or any mixture of two or more.
Asbestos packing, asbestos cloth	Seals or sealing strips on lightweight walls required to be fire resistant (at ceiling, floor, joints between elements, wall terminations) Seals on pipe and duct feed-throughs in walls and ceilings Seals between flanges of ventilation ducts Seals on fire-resistant glazing, shelter doors, chimney soot doors Seals and insulation on heat-generation systems, hot pipes and hot valves Fire blankets Heat-resistant clothing, heat-resistant gloves Lining of pipe clips for hot water, steam and sprinkler pipes Lamp wicks Mantles for gas lamps	Predominantly chrysotile (80 %–100 %); crocidolite for acid-resistant applications
Asbestos millboards	Sealing strips on lightweight walls required to be fire resistant (at ceiling, floor, joints between elements, wall terminations) Substructure of luminaries (lighting fixtures) Bottom coating of wooden windowsills over radiators	Chrysotile 80 %–100 %
Asbestos foams	Infilling (sealing) of movement joints Seals at fire shutters and fire barriers	Chrysotile ~50 %

ISO 22262-1:2012(E)

Table A.1 (continued)

Product	Examples of application	Typical asbestos type and mass fraction
Sprayed asbestos	<p>Contour-following fire-resistant coating of steel structures</p> <p>Coating of ceilings and walls in music auditoria, theatres, churches, garages, industrial rooms (for noise protection)</p> <p>Sealing off openings for cable, pipe and duct feed-throughs through walls required to be fire resistant</p> <p>Encasing of ventilation ducts</p>	<p>Chrysotile, crocidolite or amosite 40 %–70 %, also mixtures of mineral wool with either 20 % amosite or up to 30 % chrysotile. Other mixtures include 15 % chrysotile with either perlite or vermiculite, and gypsum.</p> <p>Sprayed vermiculite coatings (with or without chrysotile) can contain up to 2 % tremolite, some of which can be asbestiform.</p> <p>Several per cent of tremolite asbestos (Japan)</p>
Sprayed decorative coatings (texture coats)	Coating of ceilings and walls to provide a textured surface which masks irregularities	Chrysotile <5 %. Some constituents can also contain tremolite. Some of the tremolite can be asbestiform.
Gypsum wallboard joint compounds	Provides smooth joint between adjacent panels	Chrysotile <5 %. Some constituents can also contain low mass fractions of tremolite.
Asbestos-containing troweled-on compositions and putty	<p>Grouting of prefabricated concrete components</p> <p>Sealing of movement joints</p> <p>Pipe feeds through walls and ceilings</p> <p>Door casings of fire-resistant doors</p> <p>Anti-drumming coatings (car preservation)</p> <p>Coating of underwater structures</p> <p>Baseboard coating on house walls</p>	Chrysotile <20 %
Asbestos-containing floorings	<p>Reinforcement in flexible sheets</p> <p>Rot-resistant support layer as underlay of cushion PVC flooring materials</p>	<p>Chrysotile 10 %–20 %</p> <p>Chrysotile 80 %–100 %</p>
Asphalt or PVC asbestos floor tiles	Reinforcement	Asphalt tiles containing chrysotile <35 %, PVC tiles containing chrysotile <20 %
Rubberized asbestos seals	Gaskets for pipe flanges	Chrysotile 50 %–90 %
Asbestos-containing friction products	<p>Brake linings</p> <p>Brake bands</p> <p>Clutch linings</p>	Chrysotile 10 %–70 %
Acid-resistant containers	<p>Lead-acid battery boxes</p> <p>Drums for acid</p>	Crocidolite 10 %–50 %
Filter media	<p>Air filters</p> <p>Liquid filters</p> <p>Sterile and aseptic filters</p> <p>Clarifying sheets</p> <p>Diaphragms for chloralkali electrolysis processes</p> <p>Filtration media for Gooch crucibles</p>	<p>Chrysotile, rarely amosite 95 %</p> <p>For Gooch crucibles, 100 % tremolite or anthophyllite</p>

ISO 22262-1:2012(E)

Table A.1 (continued)

Product	Examples of application	Typical asbestos type and mass fraction
Talc (asbestos content dependent on deposit)	Release agents for electric cables, rubber products Release agents in the confectionery industry Tailor's chalk Paper manufacture Medicine, cosmetics	Chrysotile and/or actinolite/ tremolite. Some of the actinolite/ tremolite can be asbestiform
Vermiculite (exfoliated)	Attic and wall cavity insulation Fireproofing Horticultural products	Depends on the source of the vermiculite. Vermiculite from Montana, USA, can contain up to 6 % of a mixture of amphibole types, some of which can be asbestiform
Industrial minerals: wollastonite, sepiolite, attapulgite	Ceramics manufacture Plastics fillers Surfacing materials and joint compounds Ceiling tiles Drilling muds (attapulgite)	Depends on the source of the mineral. Can contain several per cent of tremolite or actinolite, some of which can be asbestiform.
Industrial minerals: calcite, dolomite and gypsum	Manufacture of building materials Industrial uses	Depends on the source of the mineral. Carbonate minerals can contain several per cent of tremolite or actinolite, some of which can be asbestiform
Industrial minerals: mica	Ceramics manufacture Manufacture of building materials	Depends on the source of the mineral. Can contain tremolite or actinolite, some of which can be asbestiform
Asphalt surfacings	Road construction	Chrysotile, generally ≤ 1 %
Wall and ceiling plasters	Interior wall and ceiling coatings, with or without aggregate and fibres such as animal hair or jute	Chrysotile. Generally locally mixed and inhomogeneous. Can be any mass fraction up to approximately 3 %
Drilling muds	Oil exploration, rock drilling	Chrysotile. Often the chrysotile is very fine and short, sometimes originating from Coalinga, California. Can contain <100 % chrysotile
Chemical products for construction, and other products	Bitumen, roofing and sealing sheets Sealing putties Glazing putties Bituminous coatings Fillers and sealers Jointing compounds Paints Glues Fire retardants Sub-floor protection	Chrysotile <30 % Chrysotile <2 % Chrysotile <4 % Chrysotile <30 % Chrysotile <25 % Chrysotile <5 % Chrysotile <9 % Chrysotile <4 % Chrysotile <10 % Chrysotile <4 %

ISO 22262-1:2012(E)

Annex B (normative)

Interference colour chart

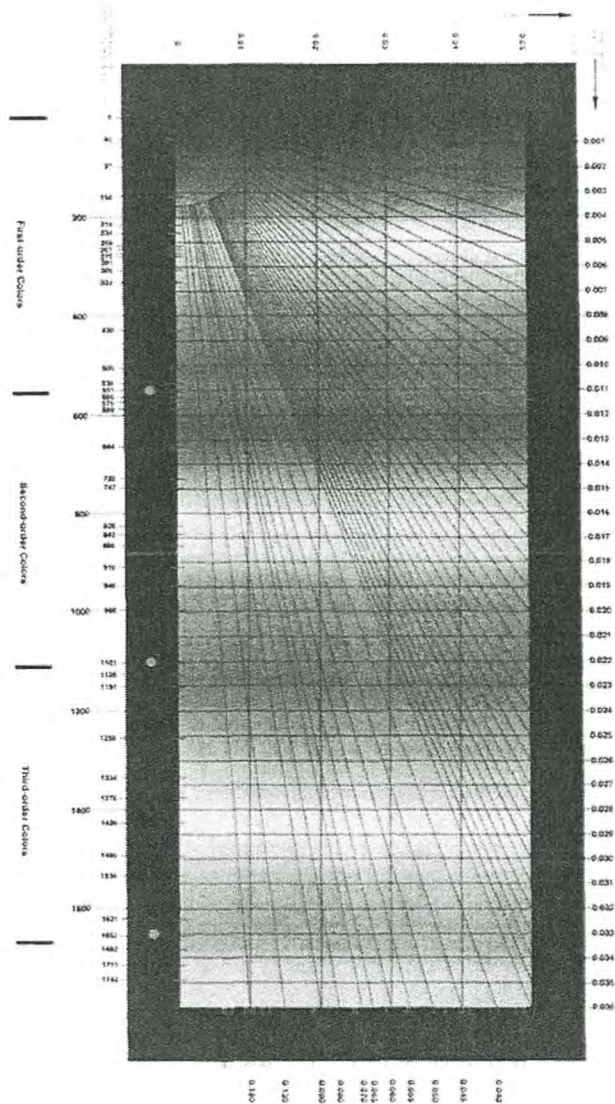


Figure B.1 — Interference colour chart

ISO 22262-1:2012(E)

Annex C (normative)

Dispersion staining charts

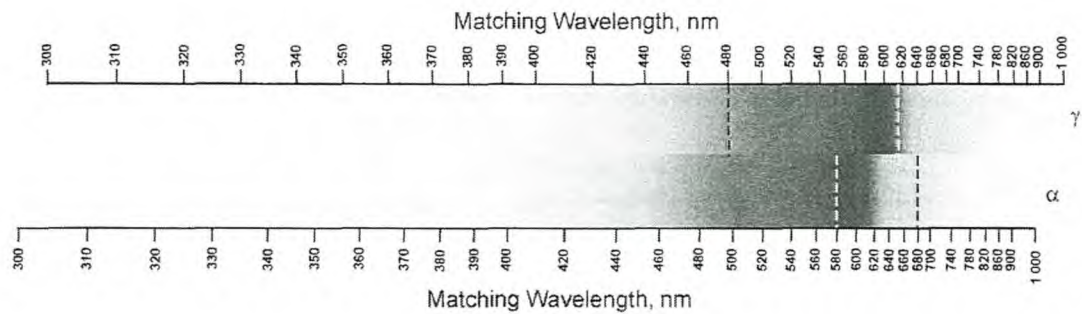


Figure C.1 — Central stop dispersion staining colours for chrysotile in 1,550 RI liquid

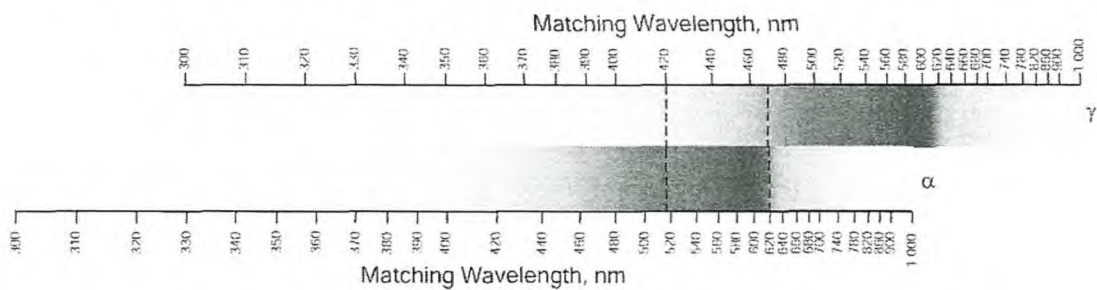


Figure C.2 — Central stop dispersion staining colours for amosite in 1,680 RI liquid

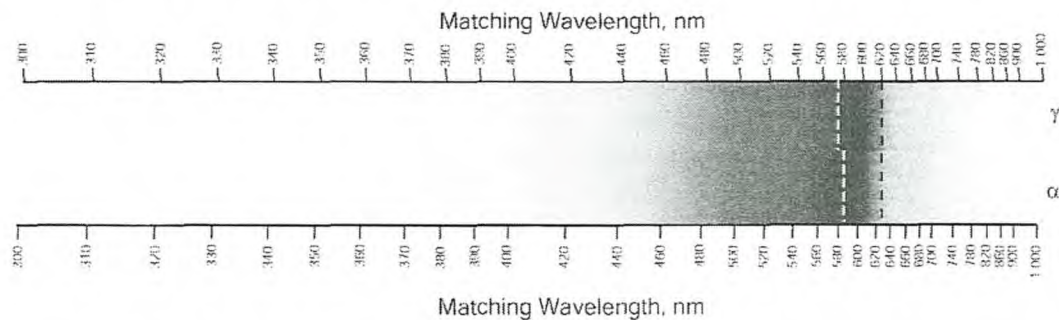


Figure C.3 — Central stop dispersion staining colours for crocidolite in 1,700 RI liquid

ISO 22262-1:2012(E)

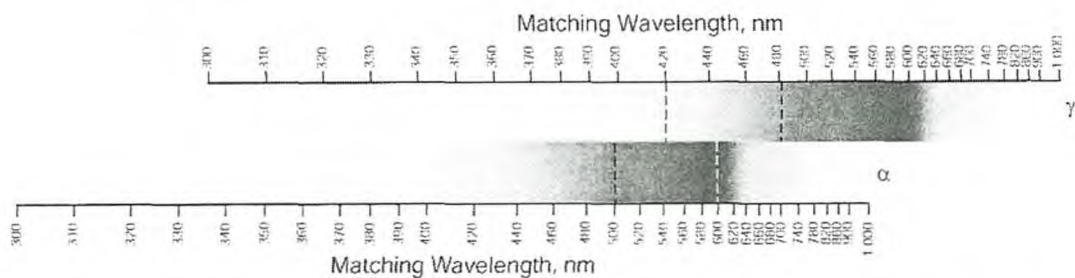


Figure C.4 — Central stop dispersion staining colours for tremolite in 1,605 RI liquid

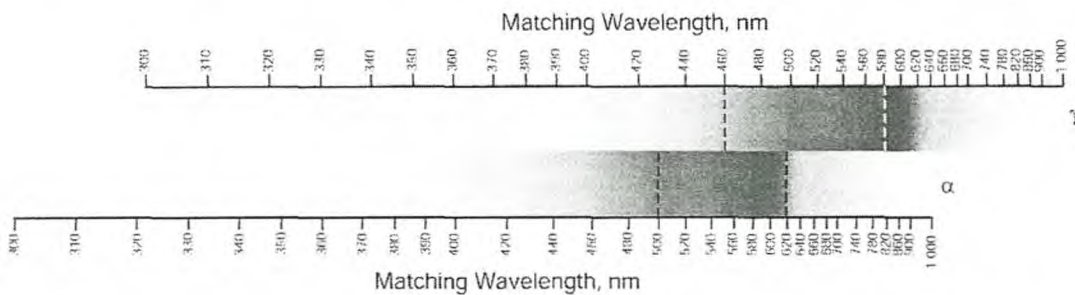


Figure C.5 — Central stop dispersion staining colours for actinolite in 1,630 RI liquid

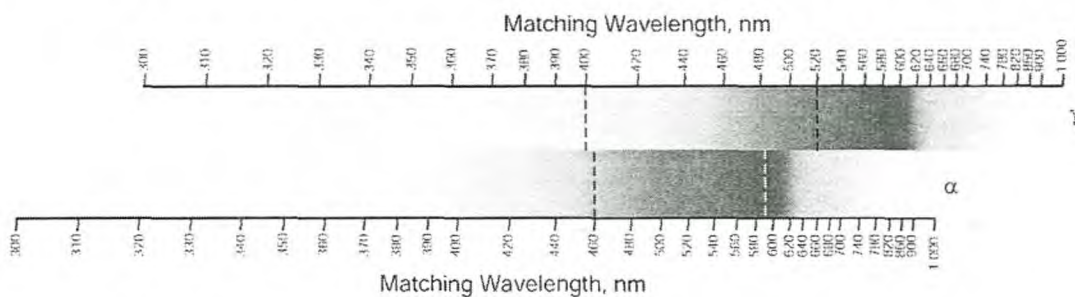


Figure C.6 — Central stop dispersion staining colours for anthophyllite in 1,605 RI liquid

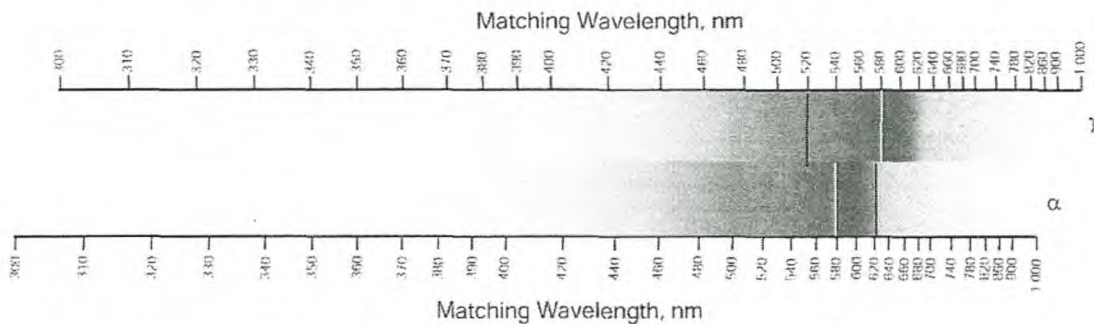


Figure C.7 — Central stop dispersion staining colours for richterite/winchite
asbestos in 1,630 RI liquid

Annex D
(normative)

**Asbestos identification by PLM and dispersion staining
in commercial materials**



**Figure D.1 — PLM micrograph of SRM 1866
chrysotile in 1,550 RI liquid — Crossed
polars with 530 nm retardation plate**



**Figure D.2 — PLM micrograph of SRM 1866
chrysotile in 1,550 RI liquid — Crossed
polars with 530 nm retardation plate**



**Figure D.3 — SRM 1866 chrysotile in 1,550 RI
liquid viewed in dispersion staining — Fibre
length parallel to polarizer vibration direction**



**Figure D.4 — SRM 1866 chrysotile in 1,550 RI
liquid viewed in dispersion staining — Fibre
length normal to polarizer vibration direction**

ISO 22262-1:2012(E)



Figure D.5 — PLM micrograph of SRM 1866 amosite in 1,680 RI liquid — Crossed polars with 530 nm retardation plate

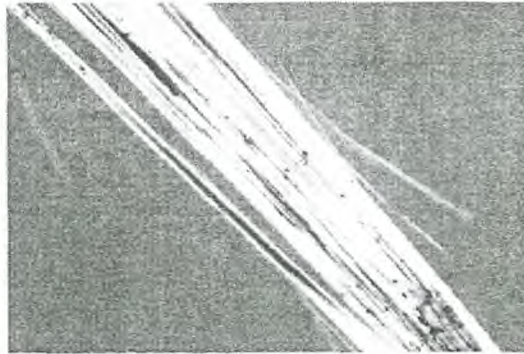


Figure D.6 — PLM micrograph of SRM 1866 amosite in 1,680 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.7 — SRM 1866 amosite in 1,680 RI liquid viewed in dispersion staining — Fibre length parallel to polarizer vibration direction

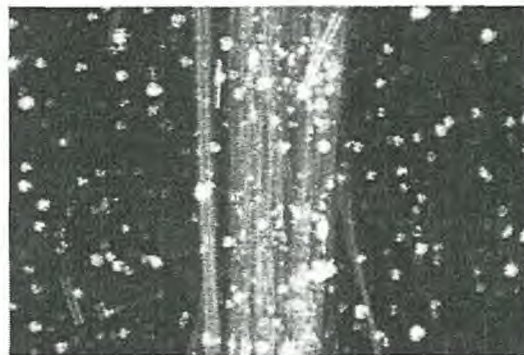


Figure D.8 — SRM 1866 amosite in 1,680 RI liquid viewed in dispersion staining — Fibre length normal to polarizer vibration direction

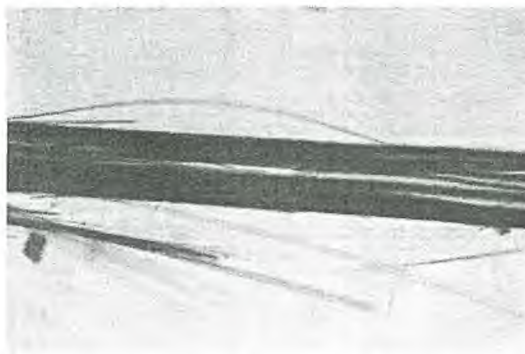


Figure D.9 — Heated amosite in 1,680 RI liquid viewed in plane polarized light — Fibre length parallel to polarizer vibration direction



Figure D.10 — Heated amosite in 1,680 RI liquid viewed in plane polarized light — Fibre length parallel to polarizer vibration direction

ISO 22262-1:2012(E)

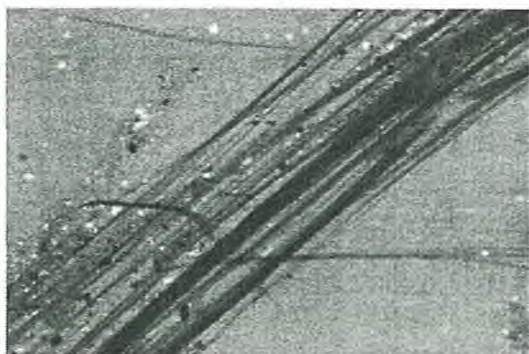


Figure D.11 — PLM micrograph of SRM 1866 crocidolite in 1,700 RI liquid — Crossed polars with 530 nm retardation plate

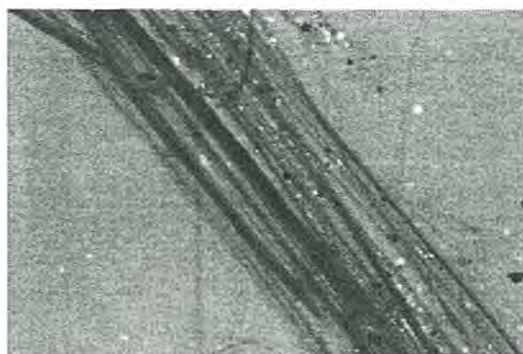


Figure D.12 — PLM micrograph of SRM 1866 crocidolite in 1,700 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.13 — SRM 1866 crocidolite in 1,700 RI liquid in plane polarized light — Fibres parallel to polarizer vibration direction

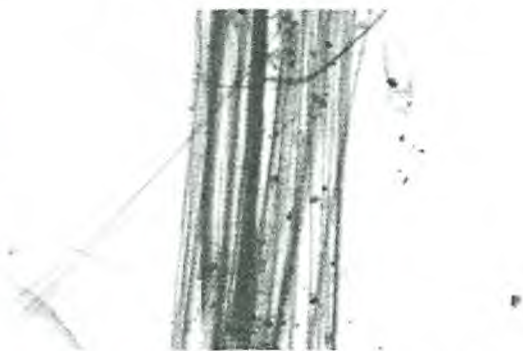


Figure D.14 — SRM 1866 crocidolite in 1,700 RI liquid in plane polarized light — Fibres normal to polarizer vibration direction



Figure D.15 — SRM 1866 crocidolite in 1,700 RI liquid — Dispersion staining — Fibre lengths parallel to polarizer vibration direction

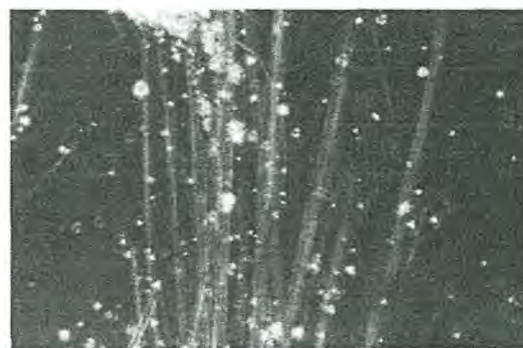


Figure D.16 — SRM 1866 crocidolite in 1,700 RI liquid — Dispersion staining — Fibre lengths normal to polarizer vibration direction

ISO 22262-1:2012(E)

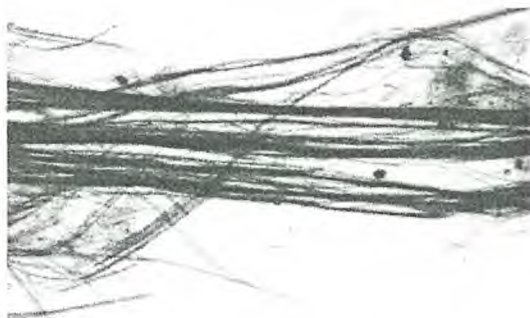


Figure D.17 — Heated crocidolite viewed in plane polarized light — Fibre length parallel to polarizer vibration direction



Figure D.18 — Heated crocidolite viewed in plane polarized light — Fibre length normal to polarizer vibration direction

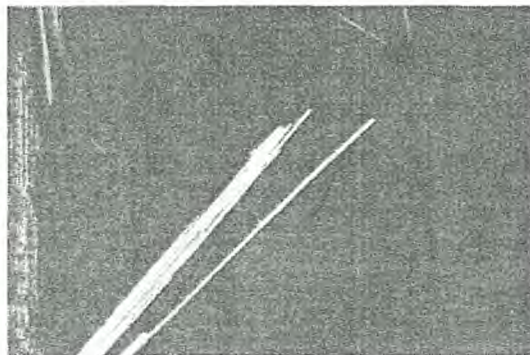


Figure D.19 — PLM micrograph of SRM 1867 tremolite in 1,605 RI liquid — Crossed polars with 530 nm retardation plate

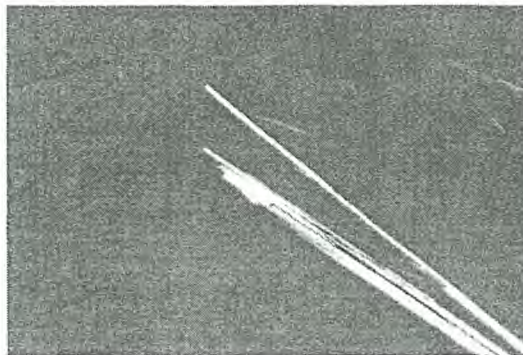


Figure D.20 — PLM micrograph of SRM 1867 tremolite in 1,605 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.21 — SRM 1867 tremolite in 1,605 RI liquid viewed in dispersion staining — Fibres at extinction position



Figure D.22 — SRM 1867 tremolite in 1,605 RI liquid viewed in dispersion staining — Fibres at extinction position

ISO 22262-1:2012(E)



Figure D.23 — PLM micrograph of SRM 1867 tremolite in 1,625 RI liquid — Crossed polars with 530 nm retardation plate

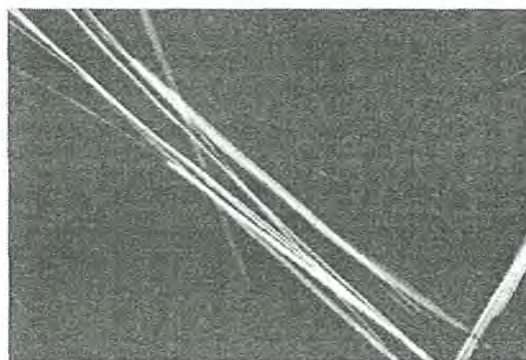


Figure D.24 — PLM micrograph of SRM 1867 tremolite in 1,625 RI liquid — Crossed polars with 530 nm retardation plate

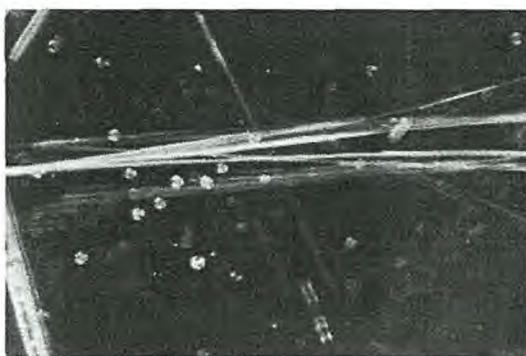


Figure D.25 — SRM 1867 tremolite in 1,625 RI liquid viewed in dispersion staining — Fibres at extinction position

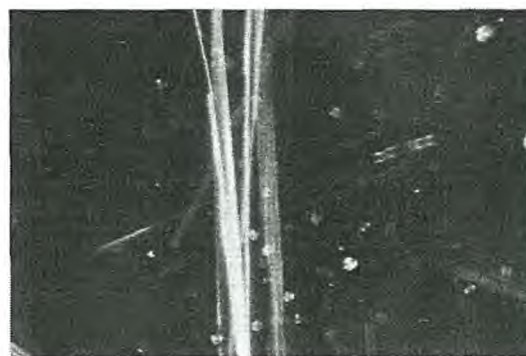


Figure D.26 — SRM 1867 tremolite in 1,625 RI liquid viewed in dispersion staining — Fibres at extinction position

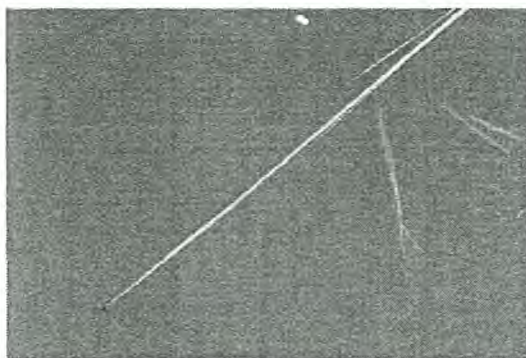


Figure D.27 — PLM micrograph of SRM 1867 actinolite in 1,630 RI liquid — Crossed polars with 530 nm retardation plate

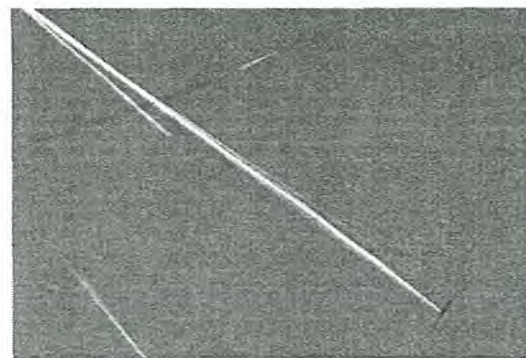


Figure D.28 — PLM micrograph of SRM 1867 actinolite in 1,630 RI liquid — Crossed polars with 530 nm retardation plate

ISO 22262-1:2012(E)



Figure D.29 — SRM 1867 actinolite in 1,630 RI liquid viewed in dispersion staining — Purple fibre at extinction position



Figure D.30 — SRM 1867 actinolite in 1,630 RI liquid viewed in dispersion staining — Light blue fibre at extinction position

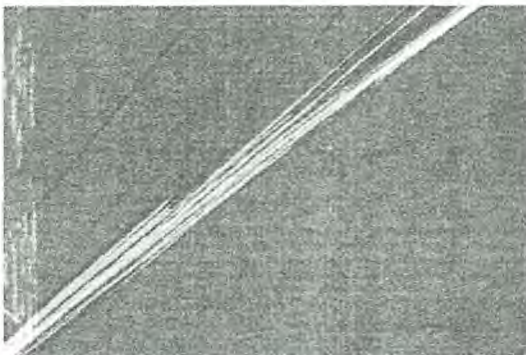


Figure D.31 — PLM micrograph of SRM 1867 anthophyllite in 1,605 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.32 — PLM micrograph of SRM 1867 anthophyllite in 1,605 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.33 — SRM 1867 anthophyllite in 1,630 RI liquid viewed in dispersion staining — Fibre lengths parallel to polarizer vibration direction

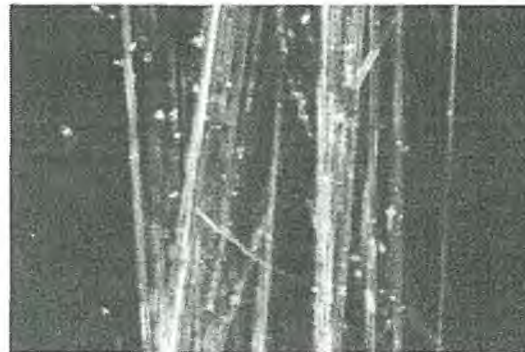


Figure D.34 — SRM 1867 anthophyllite in 1,630 RI liquid viewed in dispersion staining — Fibre lengths normal to polarizer vibration direction

ISO 22262-1:2012(E)

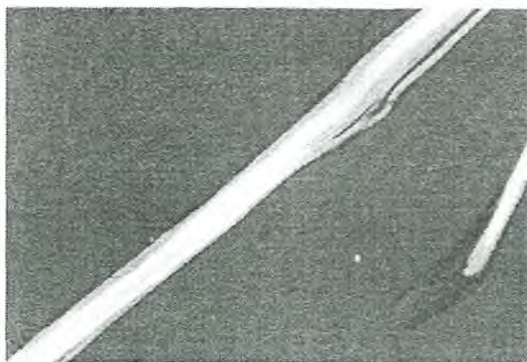


Figure D.35 — PLM micrograph of HSE tremolite in 1,605 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.36 — PLM micrograph of HSE tremolite in 1,605 RI liquid — Crossed polars with 530 nm retardation plate

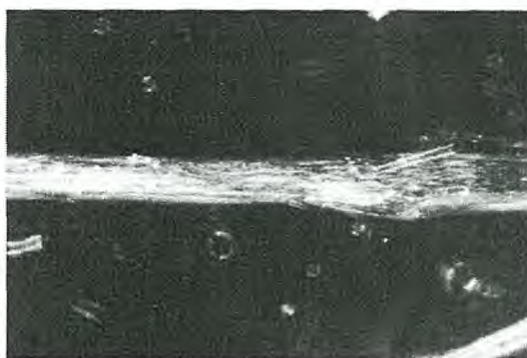


Figure D.37 — HSE tremolite in 1,605 RI liquid viewed in dispersion staining — Fibre lengths parallel to polarizer vibration direction



Figure D.38 — HSE tremolite in 1,605 RI liquid viewed in dispersion staining — Fibre lengths normal to polarizer vibration direction



Figure D.39 — PLM micrograph of HSE actinolite in 1,640 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.40 — PLM micrograph of HSE actinolite in 1,640 RI liquid — Crossed polars with 530 nm retardation plate

ISO 22262-1:2012(E)

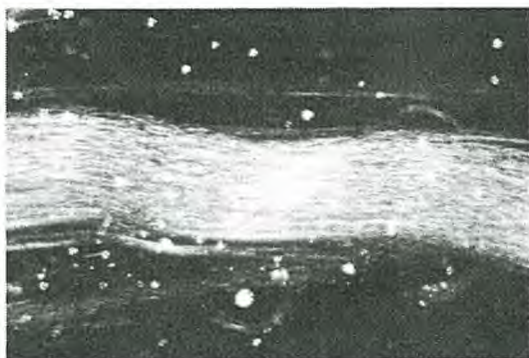


Figure D.41 — HSE actinolite in 1,640 RI liquid viewed in dispersion staining — Fibre lengths parallel to polarizer vibration direction

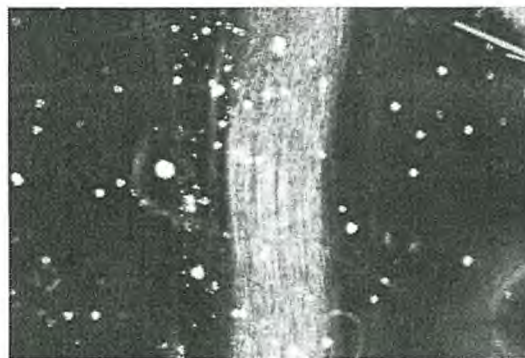


Figure D.42 — HSE actinolite in 1,640 RI liquid viewed in dispersion staining — Fibre lengths normal to polarizer vibration direction

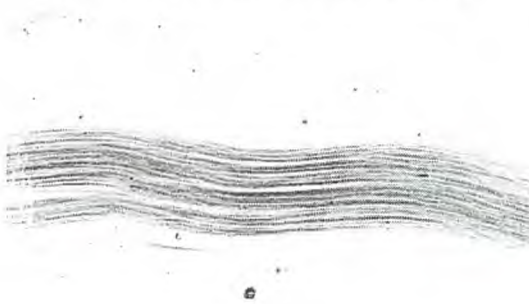


Figure D.43 — HSE actinolite in 1,640 RI liquid in plane polarized light — Fibres parallel to polarizer vibration direction



Figure D.44 — HSE actinolite in 1,640 RI liquid in plane polarized light — Fibres normal to polarizer vibration direction

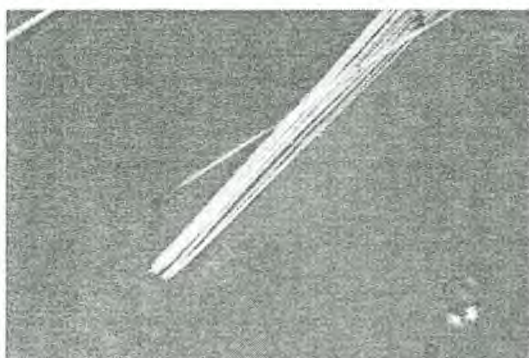


Figure D.45 — PLM micrograph of HSE anthophyllite in 1,605 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.46 — PLM micrograph of HSE anthophyllite in 1,605 RI liquid — Crossed polars with 530 nm retardation plate

ISO 22262-1:2012(E)

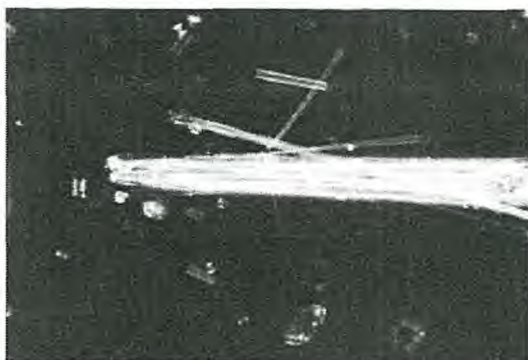


Figure D.47 — HSE anthophyllite in 1,605 RI liquid viewed in dispersion staining — Fibre lengths parallel to polarizer vibration direction

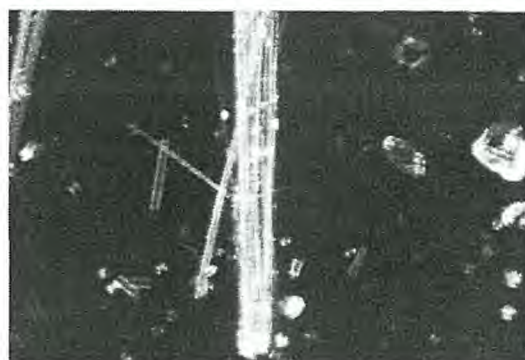


Figure D.48 — HSE anthophyllite in 1,605 RI liquid viewed in dispersion staining — Fibre lengths normal to polarizer vibration direction



Figure D.49 — PLM micrograph of richterite/winchite asbestos in 1,630 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.50 — PLM micrograph of richterite/winchite asbestos in 1,630 RI liquid — Crossed polars with 530 nm retardation plate



Figure D.51 — Richterite/winchite asbestos in 1,630 RI liquid viewed in dispersion staining — Fibres at extinction position



Figure D.52 — Richterite/winchite asbestos in 1,630 RI liquid viewed in dispersion staining — Fibres at extinction position

ISO 22262-1:2012(E)

Annex E (normative)

Asbestos identification by SEM in commercial materials

Figures E.1 to E.11 are examples of EDXA spectra collected on an SEM operating at 15 kV and using a silicon solid-state detector with a beryllium window. The SEM specimens were prepared by mounting representative fibre bundles from SRM 1866, SRM 1867, and the HSE reference asbestos varieties on adhesive tape on SEM specimen stubs. All specimens were carbon coated in a vacuum evaporator.

Prior to use of this part of ISO 22262, obtain calibration spectra from the reference standards, using the actual accelerating voltage and the specific X-ray detector.

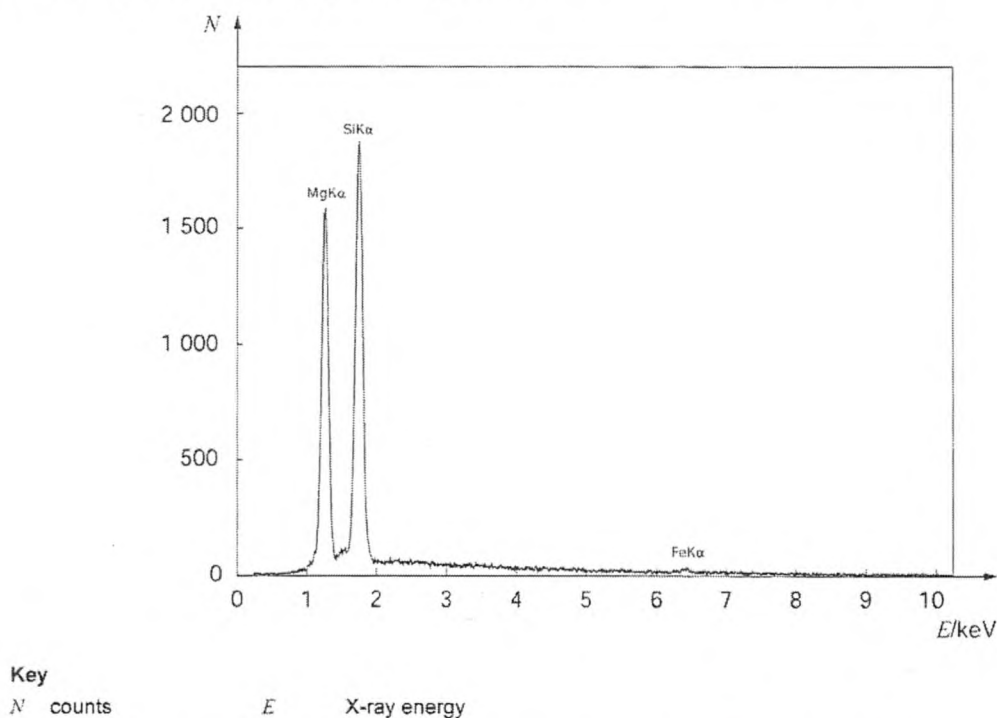


Figure E.1 — Energy dispersive X-ray spectrum obtained from SRM 1866 chrysotile

ISO 22262-1:2012(E)

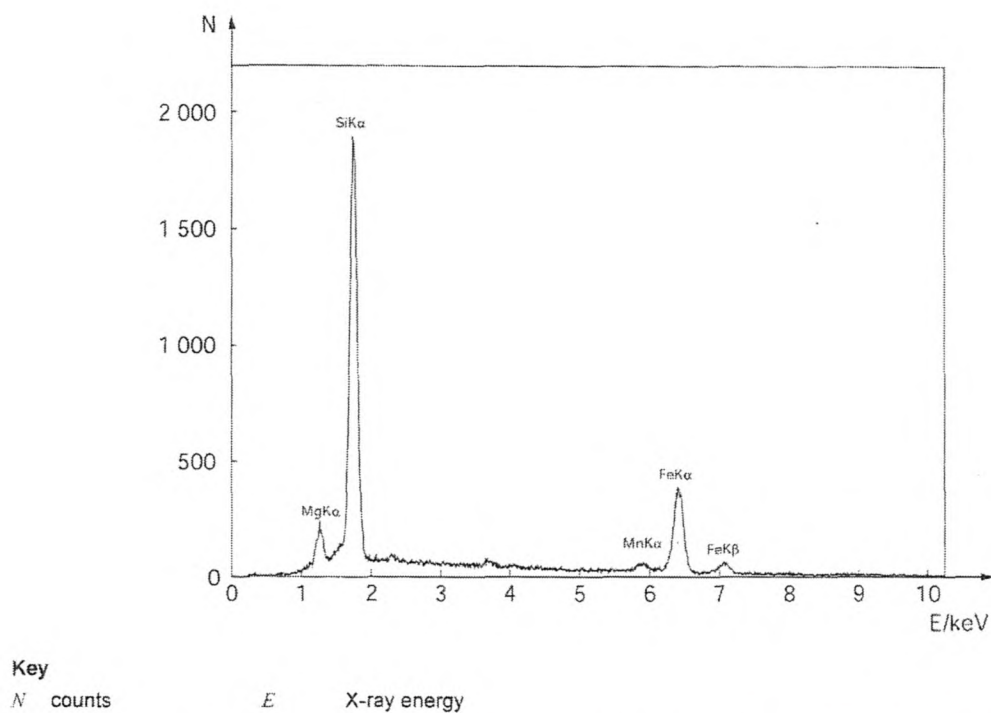


Figure E.2 — Energy dispersive X-ray spectrum obtained from SRM 1866 amosite

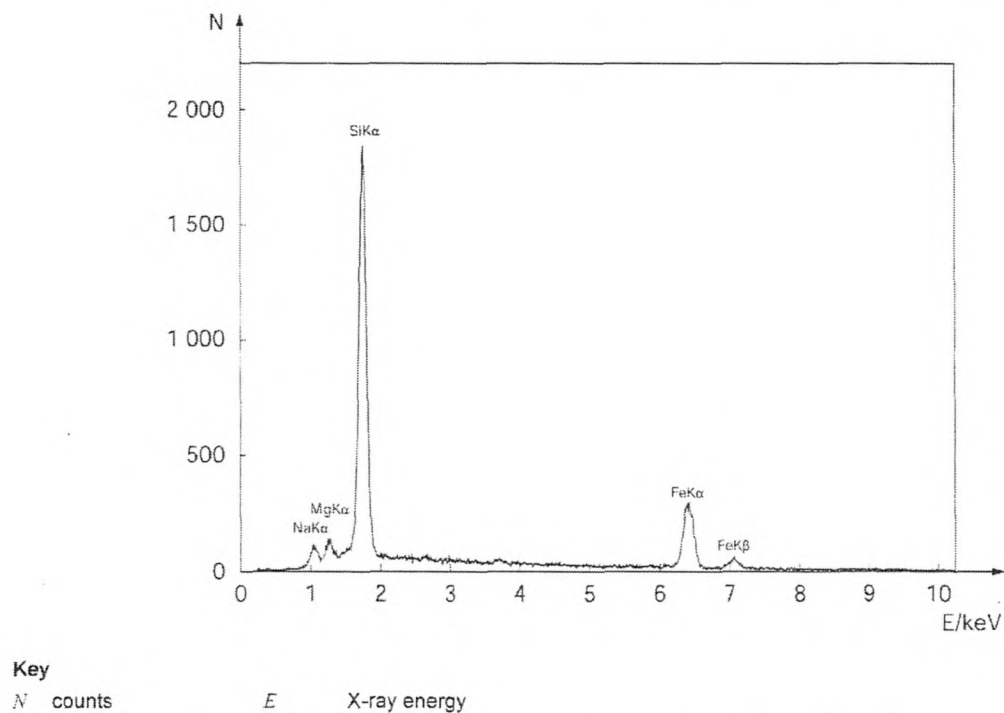
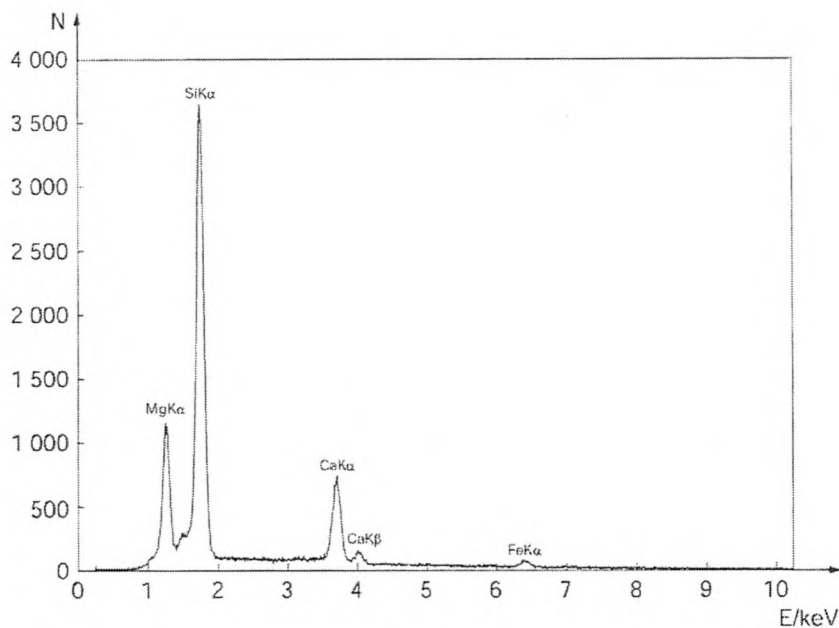


Figure E.3 — Energy dispersive X-ray spectrum obtained from SRM 1866 crocidolite

ISO 22262-1:2012(E)



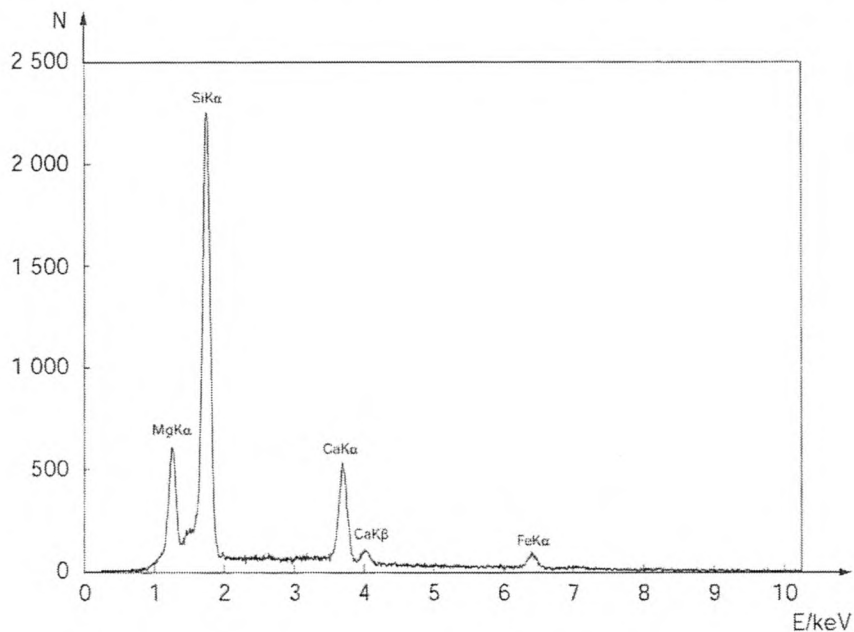
Key

N counts

E

X-ray energy

Figure E.4 — Energy dispersive X-ray spectrum obtained from SRM 1867 tremolite



Key

N counts

E

X-ray energy

Figure E.5 — Energy dispersive X-ray spectrum obtained from SRM 1867 actinolite

ISO 22262-1:2012(E)

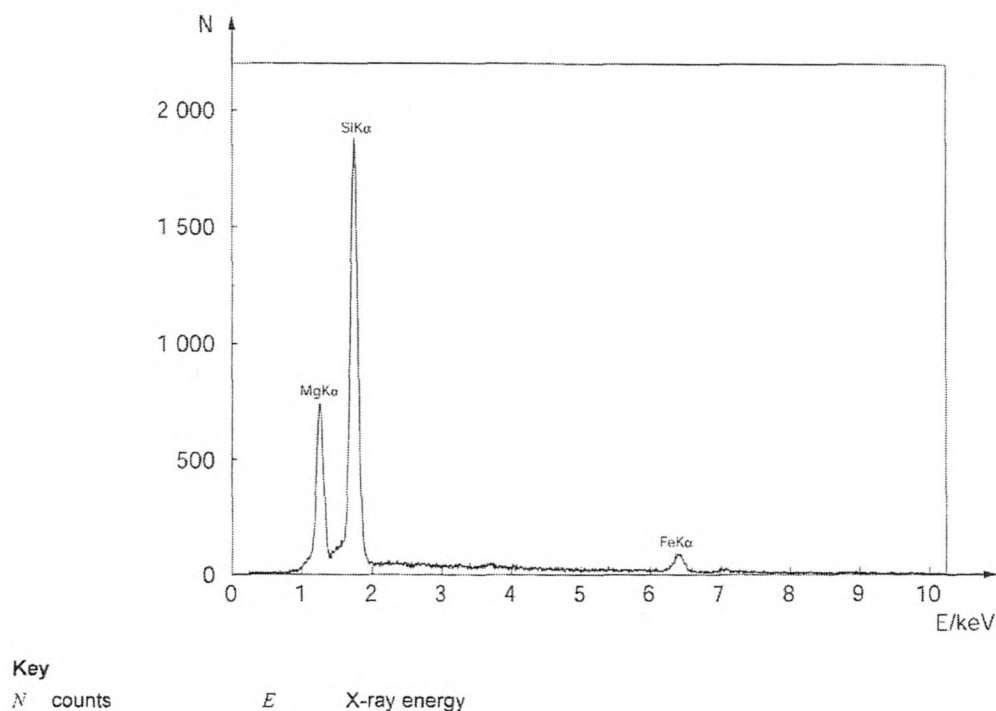


Figure E.6 — Energy dispersive X-ray spectrum obtained from SRM 1867 anthophyllite

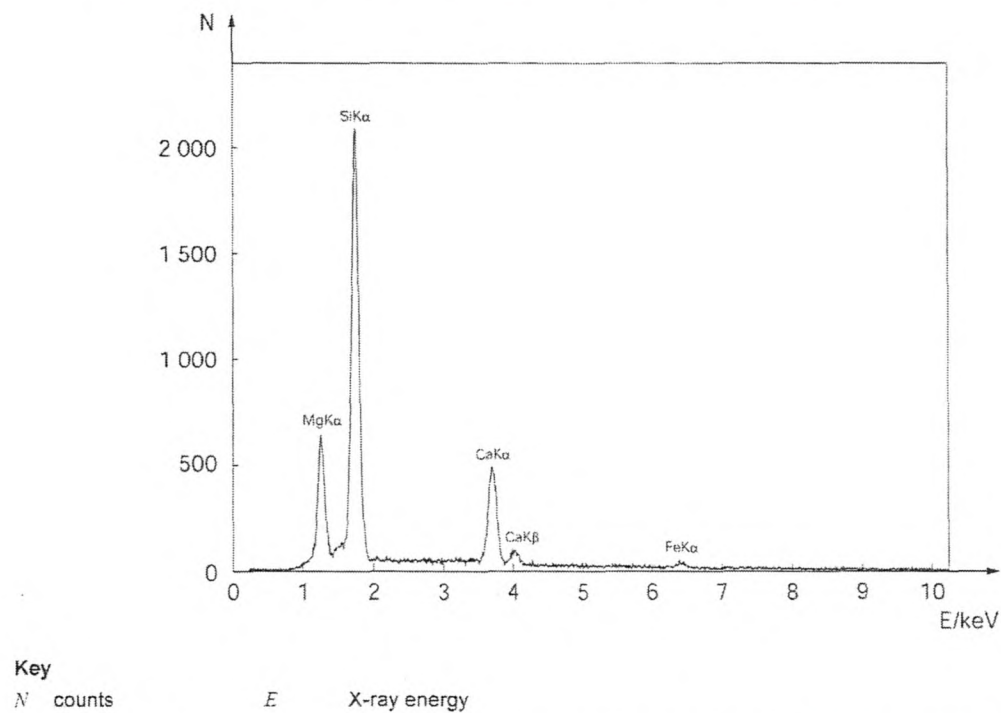
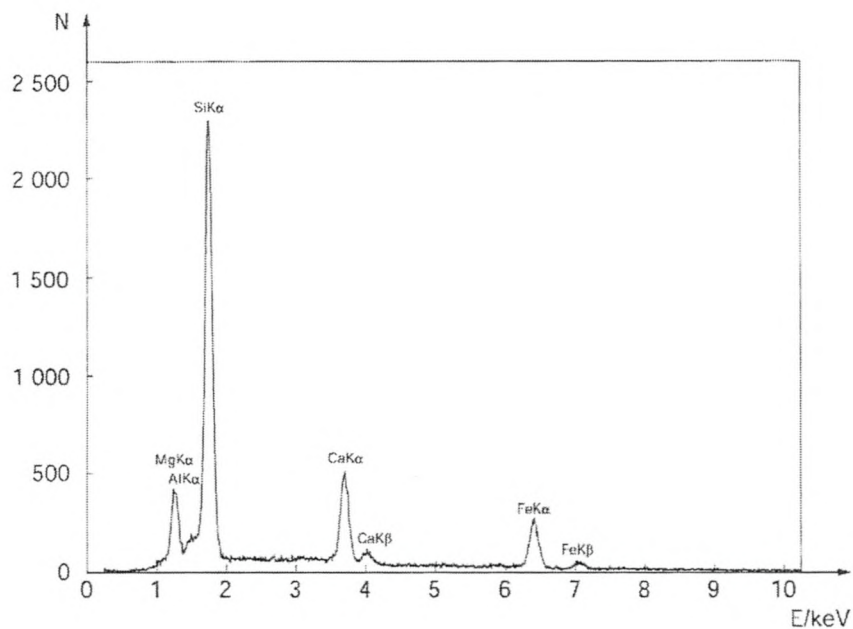


Figure E.7 — Energy dispersive X-ray spectrum obtained from HSE tremolite

ISO 22262-1:2012(E)



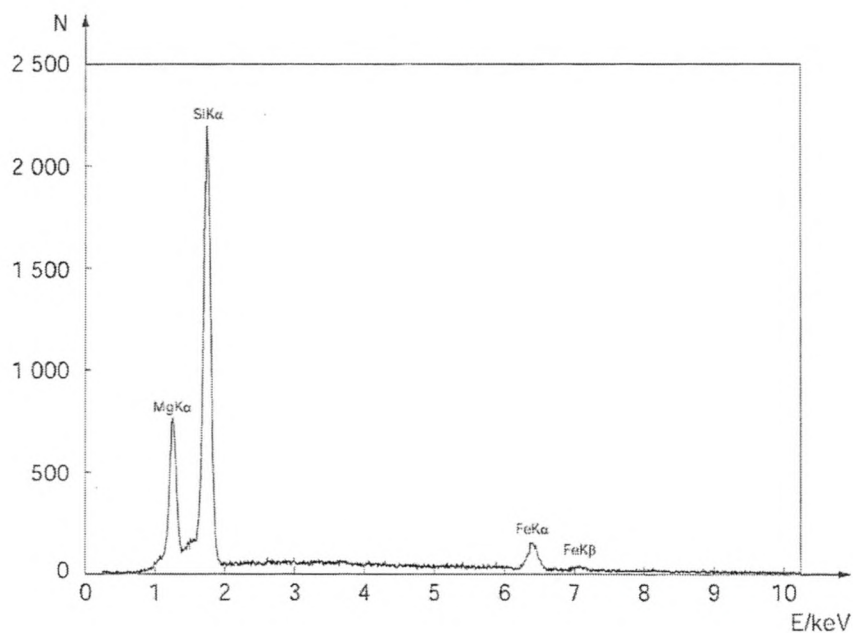
Key

N counts

E

X-ray energy

Figure E.8 — Energy dispersive spectrum obtained from HSE actinolite



Key

N counts

E

X-ray energy

Figure E.9 — Energy dispersive X-ray spectrum obtained from HSE anthophyllite

ISO 22262-1:2012(E)

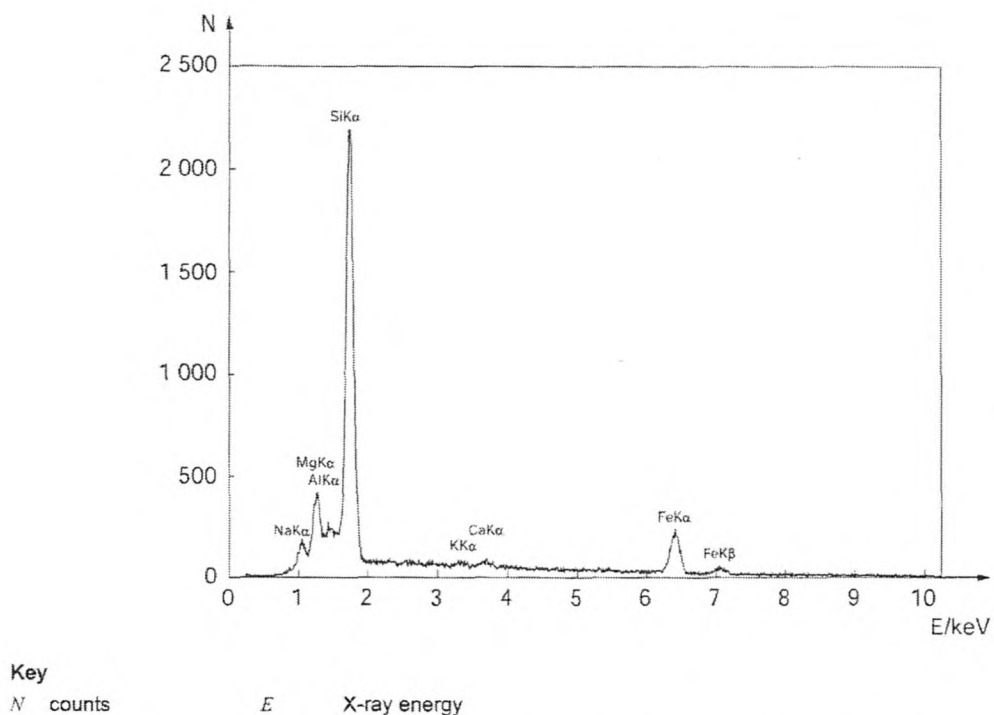


Figure E.10 — Energy dispersive X-ray spectrum obtained from Bolivian crocidolite

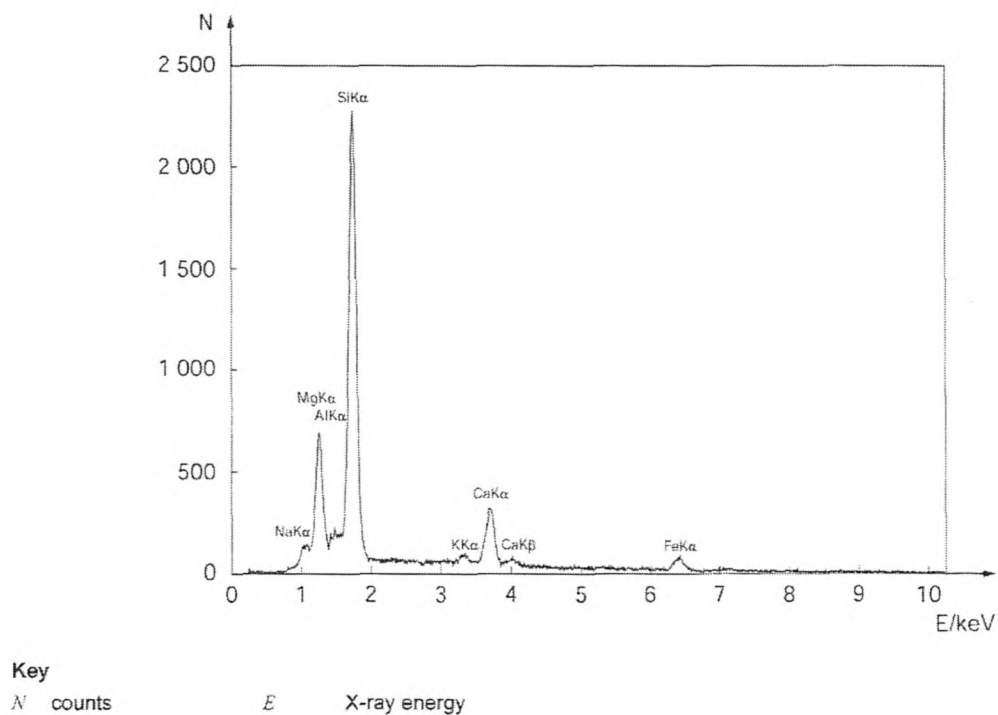


Figure E.11 — Energy dispersive X-ray spectrum obtained from richterite/winchite

ISO 22262-1:2012(E)

Annex F (normative)

Asbestos identification by TEM in commercial materials

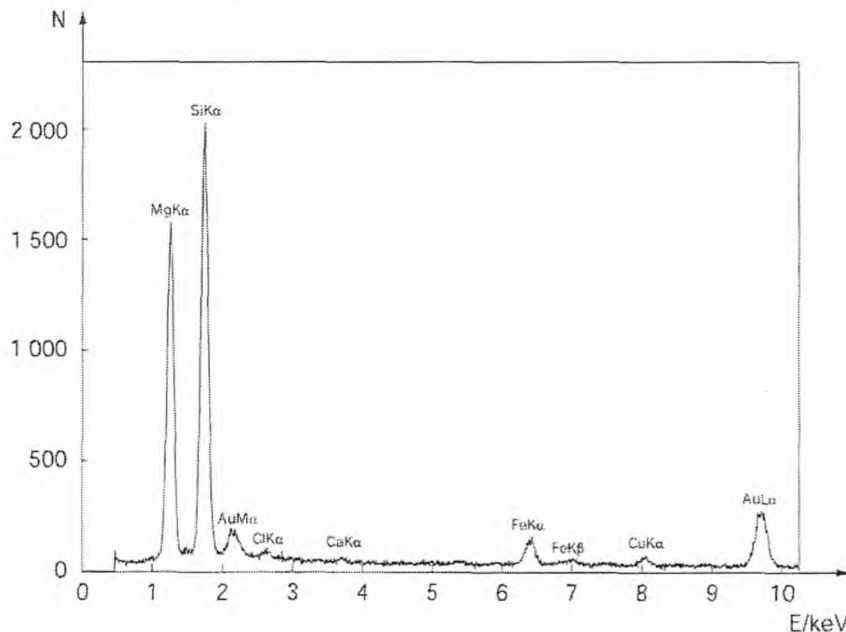
F.1 General

For the identification of asbestos in some types of bulk materials, particularly for those in which PLM examination yields ambiguous results, TEM examination can usually resolve the ambiguities and provide definitive identification of the fibres. In most cases, acquisition of an EDXA spectrum provides sufficient evidence to identify any of the asbestos varieties. Discrimination between talc and anthophyllite, however, cannot be reliably achieved on the basis of an EDXA spectrum alone, because the chemical compositions of the two minerals are very similar. Electron diffraction permits discrimination between talc and anthophyllite on the basis of their different crystal structures.

F.2 EDXA analysis

Figures F.1 to F.11 are examples of EDXA spectra collected on a TEM operating at 80 kV and using a silicon solid state detector with a beryllium window. The TEM specimens were prepared by the micropipette method from SRM 1866, SRM 1867 and HSE reference asbestos varieties. All specimens were prepared using gold grids in order to avoid interference in detection of the Na K_{α} peak by the Cu L_{α} peak which would partially overlap the sodium peak if copper specimen grids were used.

Prior to use of this part of ISO 22262, obtain calibration spectra from the reference standards, using the actual accelerating voltage and the specific X-ray detector.



Key

N counts

E

X-ray energy

Figure F.1 — Energy dispersive X-ray spectrum obtained from SRM 1866 chrysotile.
The gold and small copper peaks originate from the gold specimen grid

ISO 22262-1:2012(E)

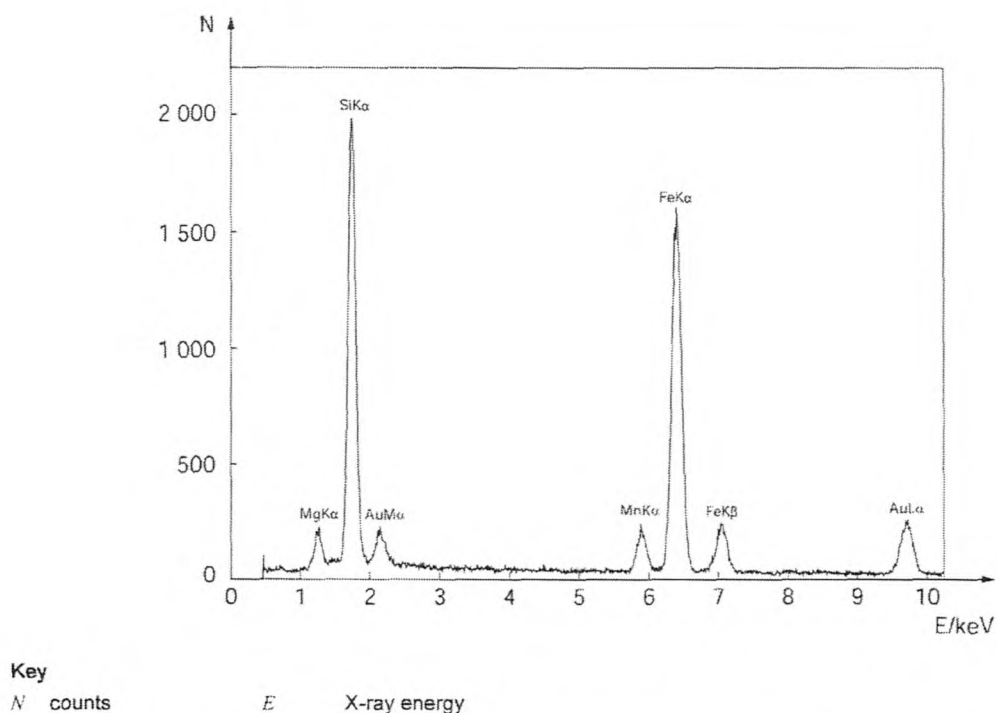


Figure F.2 — Energy dispersive X-ray spectrum obtained from SRM 1866 amosite.
The gold peaks originate from the gold specimen grid

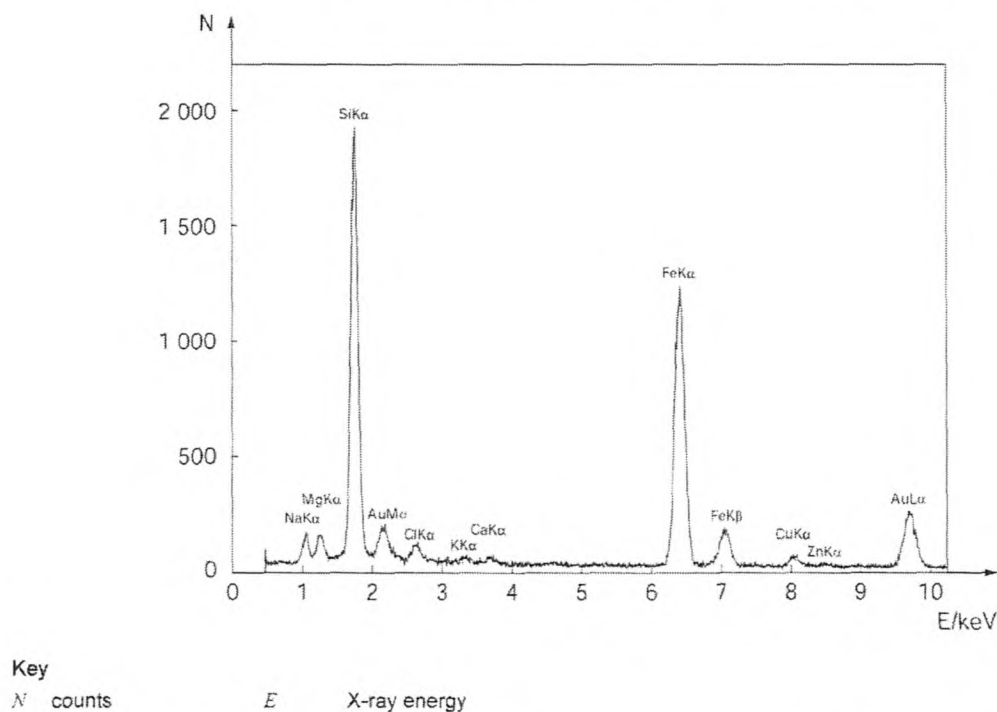


Figure F.3 — Energy dispersive X-ray spectrum obtained from SRM 1866 crocidolite.
The gold and small copper peaks originate from the gold specimen grid

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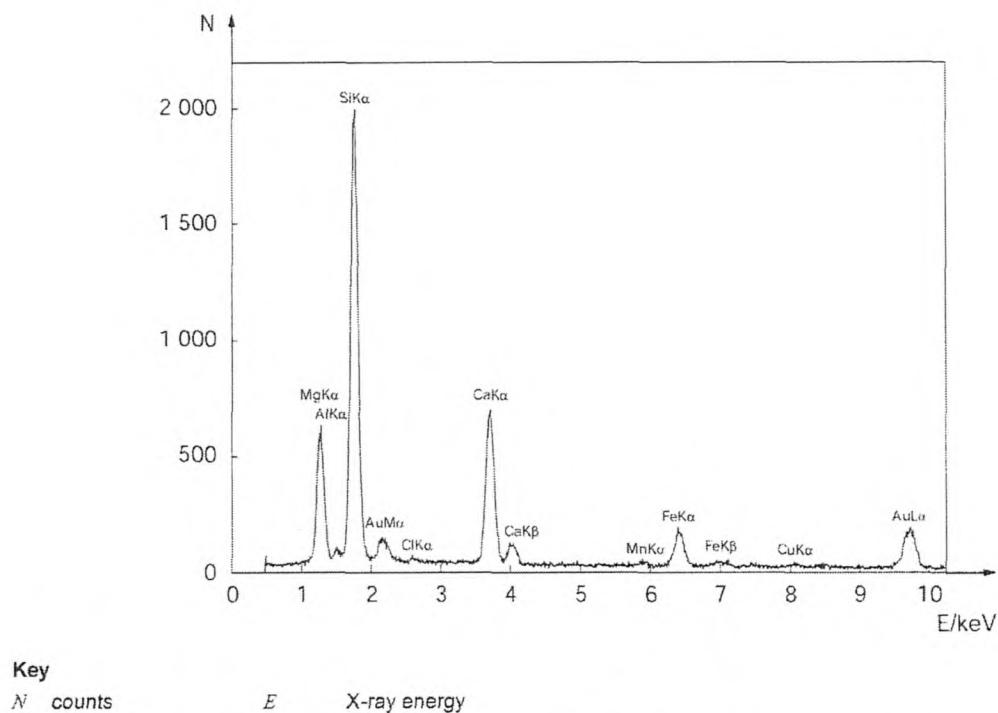


Figure F.4 — Energy dispersive X-ray spectrum obtained from SRM 1867 tremolite.
 The gold and small copper peaks originate from the gold specimen grid

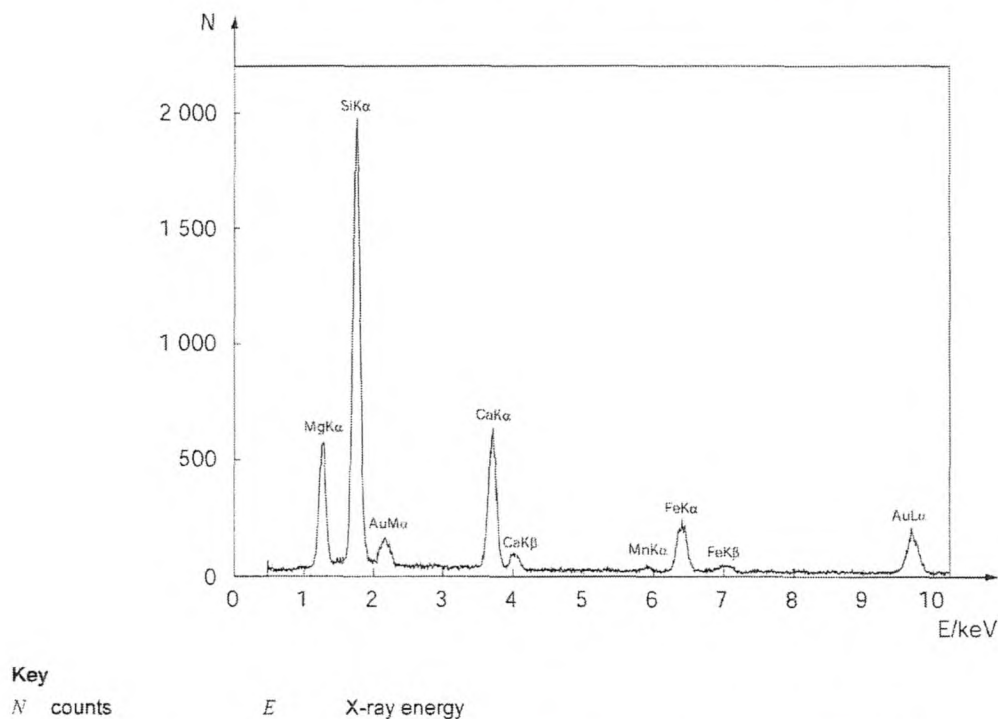
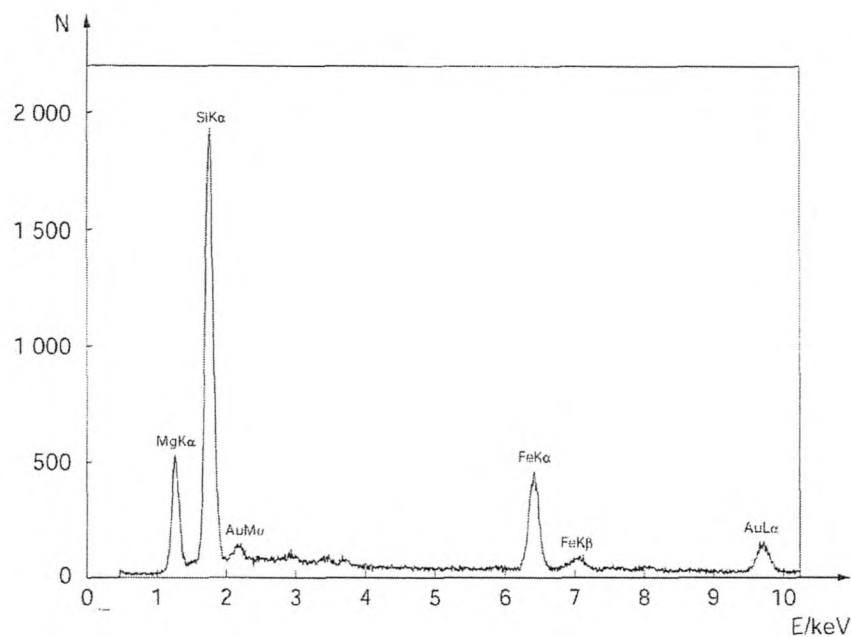


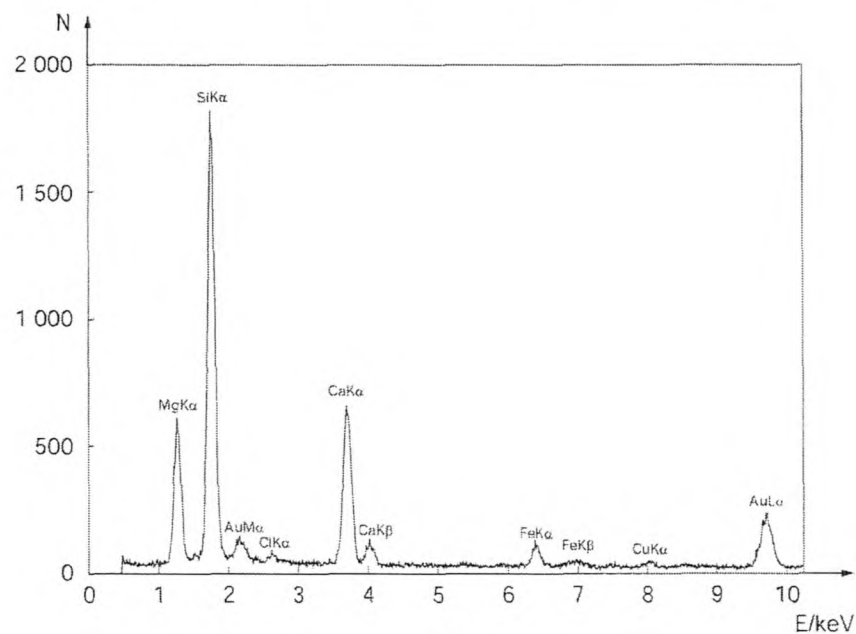
Figure F.5 — Energy dispersive X-ray spectrum obtained from SRM 1867 actinolite.
 The gold peaks originate from the gold specimen grid

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Key
N counts
E X-ray energy

Figure F.6 — Energy dispersive X-ray spectrum obtained from SRM 1867 anthophyllite.
The gold peaks originate from the gold specimen grid



Key
N counts
E X-ray energy

Figure F.7 — Energy dispersive X-ray spectrum obtained from HSE tremolite.
The gold and small copper peaks originate from the gold specimen grid

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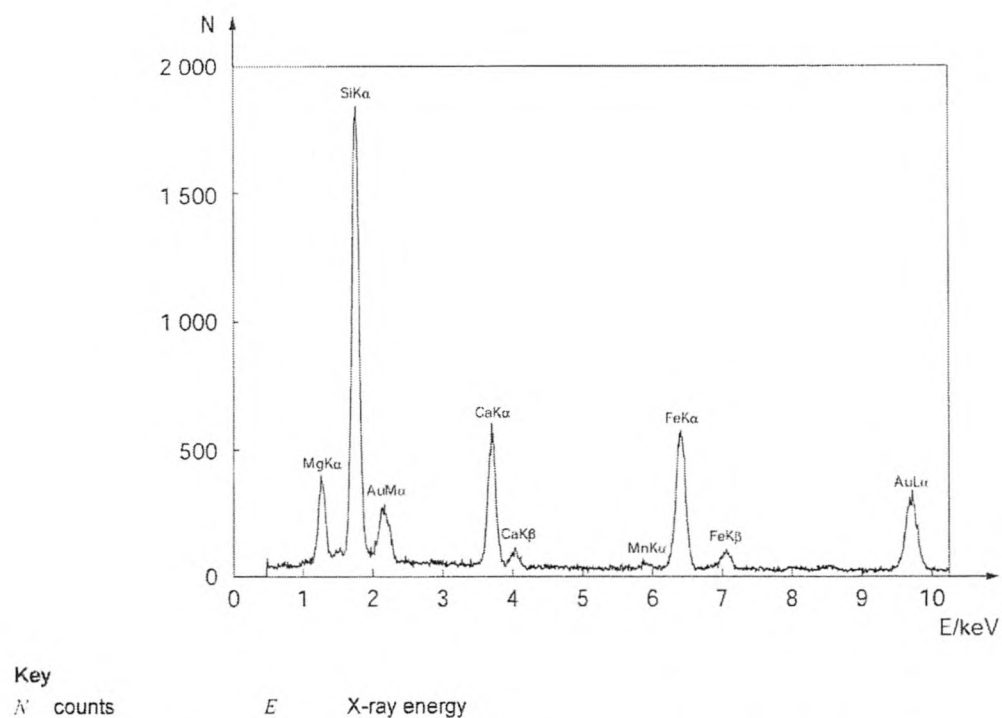


Figure F.8 — Energy dispersive X-ray spectrum obtained from HSE actinolite.
The gold peaks originate from the the gold specimen grid

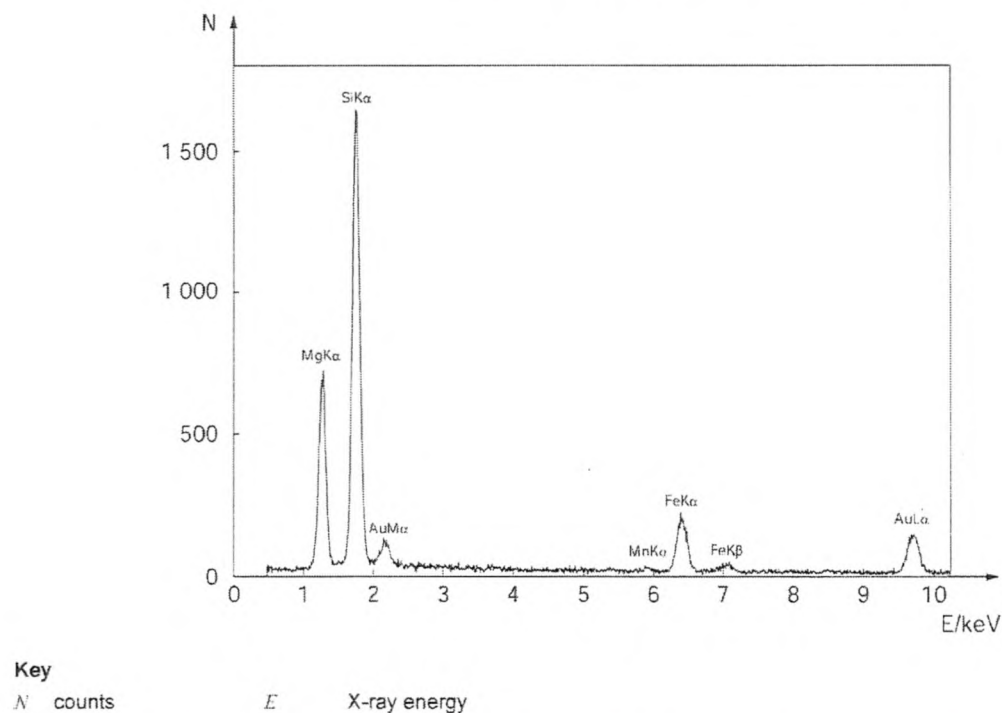
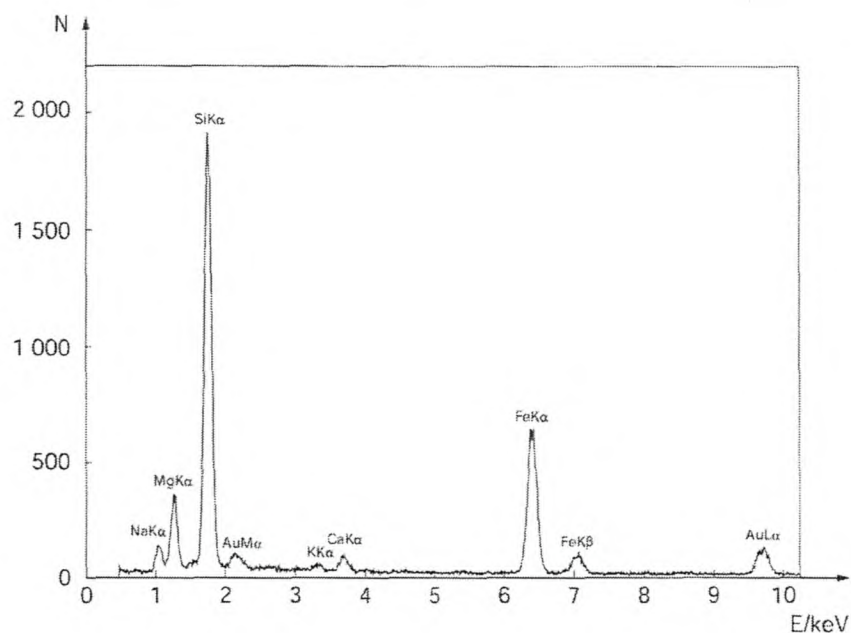


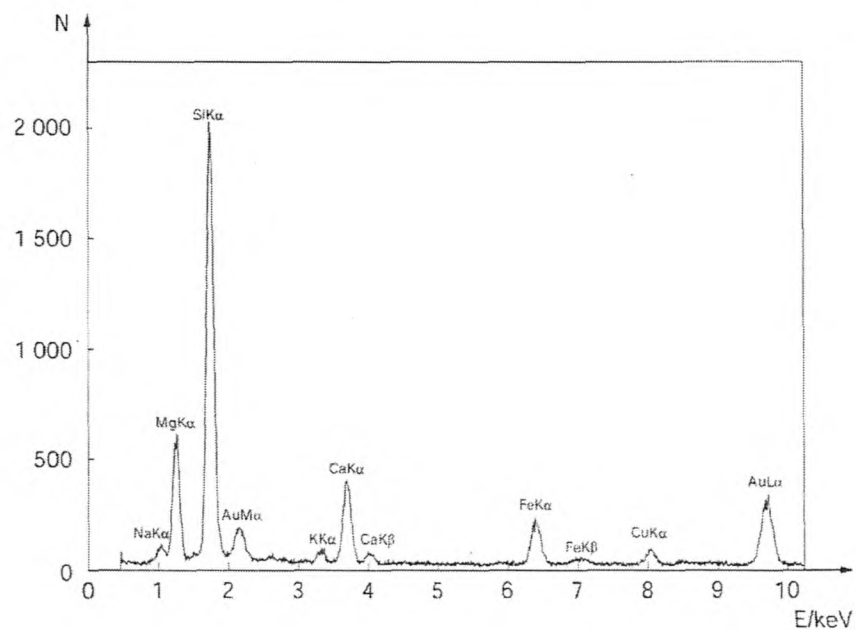
Figure F.9 — Energy dispersive X-ray spectrum obtained from HSE anthophyllite.
The gold peaks originate from the gold specimen grid

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Key
N counts
E X-ray energy

**Figure F.10 — Energy dispersive X-ray spectrum obtained from Bolivian crocidolite.
The gold peaks originate from the gold specimen grid**



Key
N counts
E X-ray energy

**Figure F.11 — Energy dispersive X-ray spectrum obtained from richterite/winchite asbestos.
The gold and small copper peaks originate from the gold specimen grid**

F.3 Electron diffraction

The ED technique can be either qualitative or quantitative. Qualitative ED consists of visual examination, without detailed measurement, of the general characteristics of the ED pattern obtained on the TEM viewing screen from a randomly oriented fibre. ED patterns obtained from fibres with cylindrical symmetry, such as chrysotile, do not change when the fibres are tilted about their axes, and patterns from randomly oriented fibres of these minerals can be interpreted quantitatively. For fibres which do not have cylindrical symmetry, only those ED patterns obtained when the fibre is oriented with a principal crystallographic axis closely parallel to the incident electron-beam direction can be interpreted quantitatively. This type of ED pattern shall be referred to as a zone-axis ED pattern. In order to interpret a zone-axis ED pattern quantitatively, it shall be recorded photographically and its consistency with known mineral structures shall be checked. A computer program may be used to compare measurements of the zone-axis ED pattern with corresponding data calculated from known mineral structures. The zone-axis ED pattern obtained by examination of a fibre in a particular orientation can be insufficiently specific to permit unequivocal identification of the mineral fibre, but it is often possible to tilt the fibre to another angle and to record a different ED pattern corresponding to another zone axis. The angle between the two zone axes can also be checked for consistency with the structure of a suspected mineral.

For visual examination of the ED pattern, the camera length of the TEM should be set to a low value of approximately 250 mm and the ED pattern should then be viewed through the binoculars. This procedure minimizes the possible degradation of the fibre by the electron irradiation. However, the pattern is distorted by the tilt angle of the viewing screen. A camera length of at least 2 m should be used when the ED pattern is recorded, if accurate measurement of the pattern is to be possible. It is necessary that, when obtaining an ED pattern to be evaluated visually or recorded, the sample height shall be properly adjusted to the eucentric point and the image shall be focused in the plane of the selected area aperture. If this is not done, there may be some components of the ED pattern which do not originate from the selected area. In general, it is necessary to use the smallest available ED aperture.

For accurate measurements of the ED pattern, it is recommended that an internal calibration standard be used. Apply a thin coating of gold, or other suitable calibration material, to the underside of the TEM specimen. This coating may be applied either by vacuum evaporation or, more conveniently, by sputtering. The polycrystalline gold film yields diffraction rings on every ED pattern and these rings provide the required calibration information. Alternatively, a calibrated objective aperture can be inserted to determine if the layer-line spacing of the ED pattern is approximately 0,53 nm, as expected for asbestos fibres (Reference [30]). This works well even when viewing a raised screen through binoculars.

To form an ED pattern, move the image of the fibre to the centre of the viewing screen, adjust the height of the specimen to the eucentric position, and insert a suitable selected area aperture into the electron beam so that the fibre, or a portion of it, occupies a large proportion of the illuminated area. The size of the aperture and the portion of the fibre shall be such that particles other than the one to be examined are excluded from the selected area. Observe the ED pattern through the binoculars. During the observation, the objective lens current should be adjusted to the point where the most complete ED pattern is obtained. If an incomplete ED pattern is still obtained, move the particle around within the selected area to attempt to optimize the ED pattern, or to eliminate possible interferences from neighbouring particles.

ED patterns can be particularly useful for differentiating fibrous talc from anthophyllite asbestos, both of which have similar EDXA spectra. ED of talc produces a pseudo-hexagonal pattern that does not change as the fibre is tilted using the goniometer. Anthophyllite asbestos, on the other hand, produces assorted spots appearing and disappearing along layer lines as the fibre is tilted using the goniometer. ED patterns can also be a useful diagnostic tool for chrysotile that is so heavily coated with matrix that EDXA is inconclusive. Detection of the 002, 110, and 130 reflections as shown in Figure F.12 in conjunction with 0,53 nm layer-line spacing confirms the presence of chrysotile.

Analysis of laboratory samples seldom requires zone-axis measurements. However, if a zone-axis ED analysis is to be attempted on the fibre, the sample shall be mounted in the appropriate holder. The most convenient holder allows complete rotation of the specimen grid and tilting of the grid about a single axis. Rotate the sample until the fibre image indicates that the fibre is oriented with its length coincident with the tilt axis of the goniometer, and adjust the sample height until the fibre is at the eucentric position. Tilt the fibre until an ED pattern appears which is a symmetrical, two dimensional array of spots. The recognition of zone-axis alignment conditions requires some experience on the part of the operator. During tilting of the fibre to obtain zone-axis

conditions, the manner in which the intensities of the spots vary should be observed. If weak reflections occur at some points on a matrix of strong reflections, the possibility of twinning or multiple

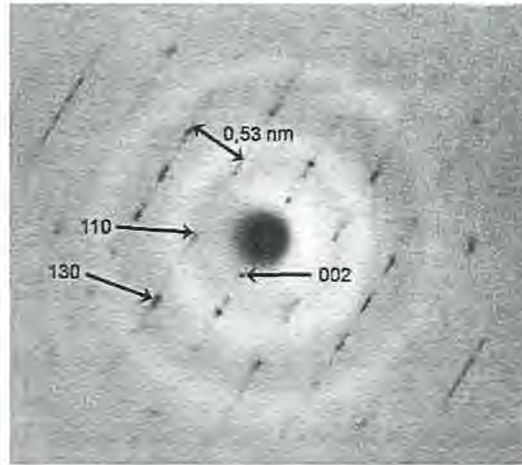


Figure F.12 — Chrysotile SAED pattern

diffraction exists, and some caution should be exercised in the selection of diffraction spots for measurement and interpretation. A full discussion of electron diffraction and multiple diffraction can be found in References [26]–[29].

It is important to recognize that not all zone-axis patterns that can be obtained are definitive. Only those patterns with closely spaced reflections corresponding to low indices in at least one direction should be recorded. Patterns in which all d -spacings are less than about 0,3 nm are not definitive. A useful guideline is that the lowest angle reflections should be within the radius of the smallest ring of the gold diffraction pattern (111), and that patterns with smaller distances between reflections are usually the most definitive. It is particularly important to recognize that when ED is used to discriminate between different minerals of similar compositions, demonstration that an ED pattern is consistent with the crystal structure of a particular mineral is not proof of identity, unless the ED pattern has also been shown to be *inconsistent* with the crystal structures of the other possible minerals.

Computer programs such as XIDENT (Reference [31]) provide a convenient way to test the consistency of any given ED pattern with the crystallographic data for individual minerals. The XIDENT program is advantageous in that no knowledge of crystal orientation is required; all possible ED patterns at all orientations are calculated and compared with the observed ED pattern. If the results obtained from one ED pattern do not resolve any ambiguity in identification of a fibre, a second ED pattern obtained at a different orientation of the fibre can be examined, and the observed tilt angle between the two orientations can be compared with the theoretical angle calculated from the suspected crystal structure. In order to use the XIDENT program, five spots, closest to the centre spot, along two intersecting lines of the zone-axis pattern are selected for measurement, as illustrated in Figure F.13. The distances of these spots from the centre spot and the four angles shown provide the required data for analysis. Since the centre spot is usually very over-exposed, it does not provide a well-defined origin for these measurements. The required distances are best obtained by measuring between pairs of spots symmetrically disposed about the centre spot, preferably separated by several repeat distances.

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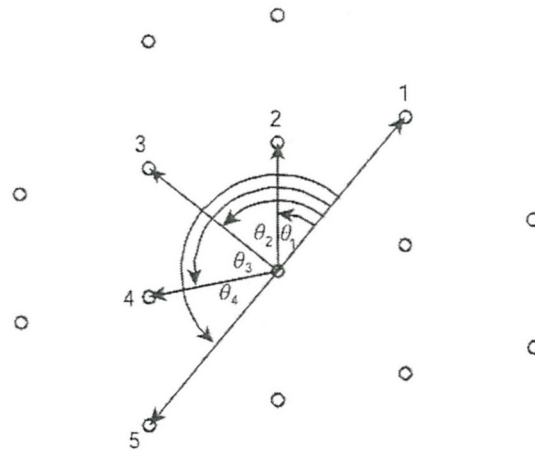


Figure F.13 — Measurement of spacings and angles in a zone axis ED pattern

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Annex G
(informative)

Example of sampling record

Date:	Samples taken by:
Building and location:	

Room:		Sample identification:	
Sampling location:			
Reference:	Plan No:	Position in plan:	
Sketch No:		Photo No:	
Sample details:			
Comments:			

ISO 22262-1:2012(E)

Annex H (informative)

Example of test report

Analysis of bulk materials for asbestos by ISO 22262-1

Date of analysis:			
Analyst:		Signature:	
<p>NOTE ISO 22262-1 refers to qualitative analysis of commercial products for asbestos.</p> <p>In this method, polarized light microscopy with dispersion staining is the default procedure for identification of asbestos. If the sample characteristics required the use of either of the optional electron microscope methods to identify asbestos, the method used is indicated. If accurate quantification of asbestos mass fraction in the range below approximately 5 % mass fraction is required for the purpose of determining the regulatory status of an asbestos-containing material, use the appropriate other parts of ISO 22262.</p>			

Sample	Asbestos	Estimated asbestos mass fraction	Non-asbestos fibres	Comments
Sample 20050411-1 Pipe covering Grey corrugated paper	Chrysotile	5 %–50 %	Cellulose Brucite	Sample ashed to remove interfering materials.
Sample 20050412-3 Pipe covering White fibrous material	Amosite Chrysotile	5 %–50 % 0,1 %–5 %	None	
Sample 20050412-4 Fireproofing from beam Blue fibrous material	Crocidolite	50 %–100 %	None	
Sample 20050413-1 Pipe covering Off-white fibrous material	None detected	0 %	Mineral wool	
Sample 20050413-2 Plaster White material	Tremolite	0,1 %–5 %	None	
Sample 20050413-3 Ceiling tile Grey fibrous material	Chrysotile	0,1 %–5 %	Mineral wool Cellulose	Chrysotile too fine to identify by PLM. Chrysotile identified by TEM method.

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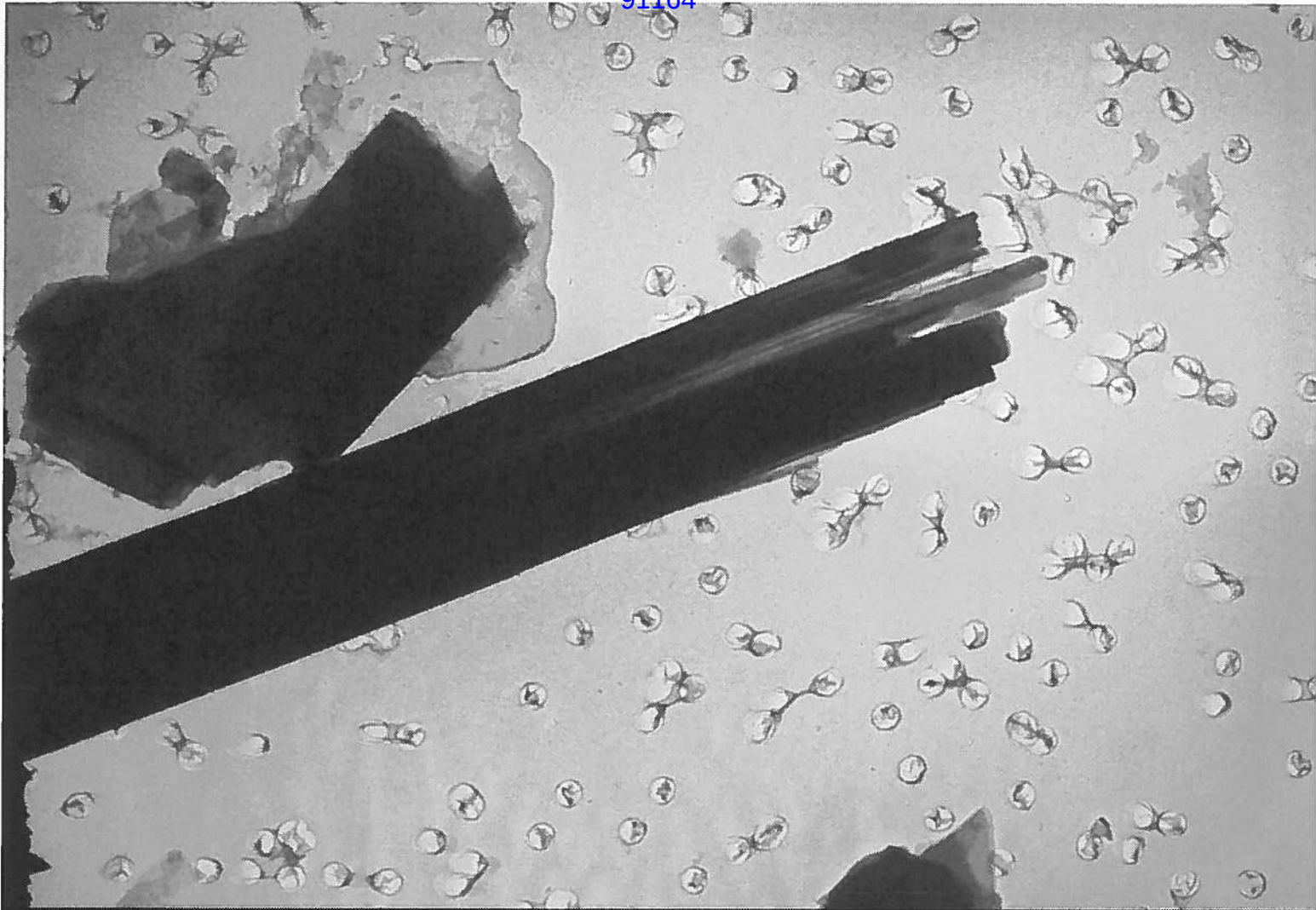
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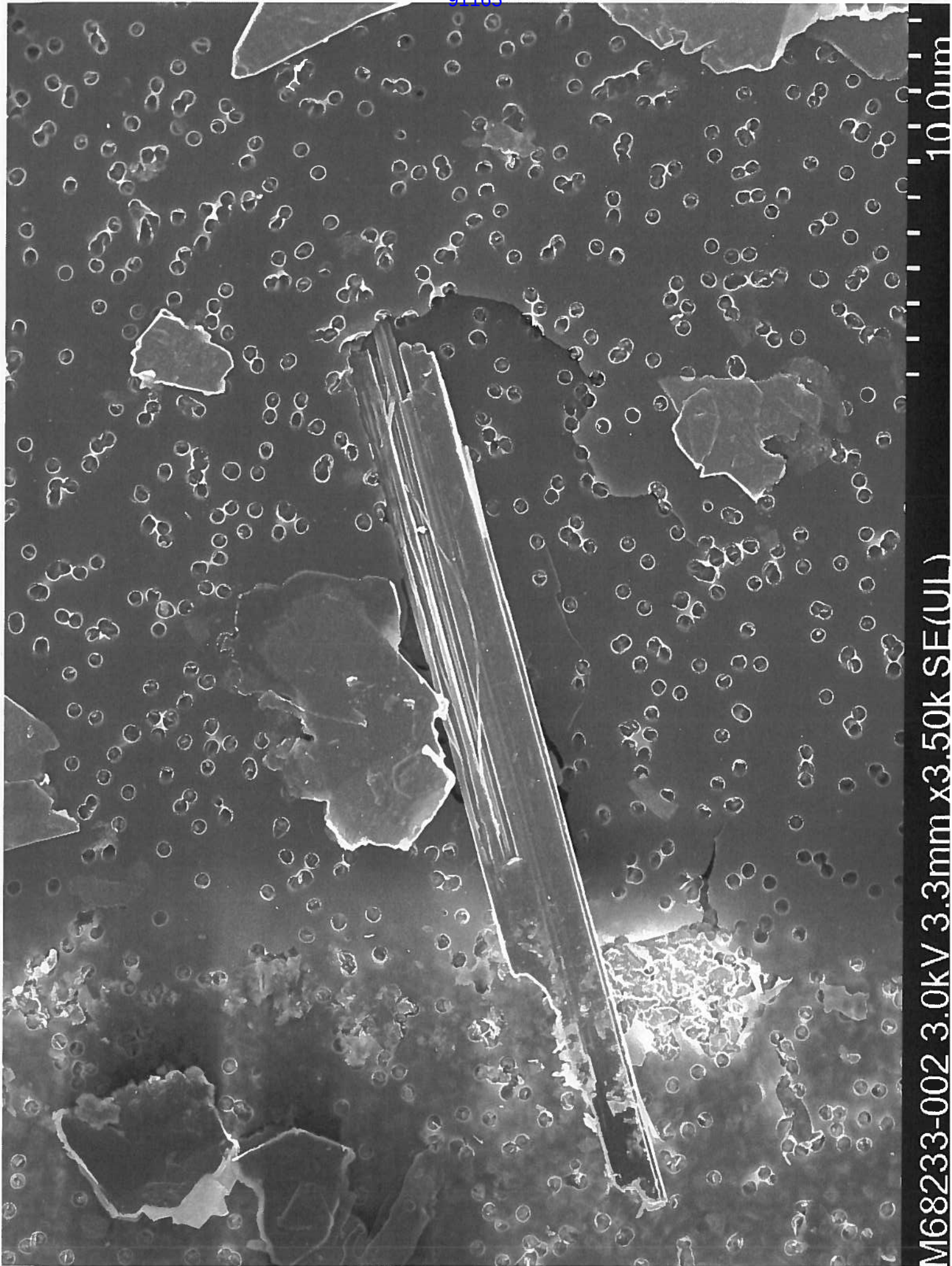
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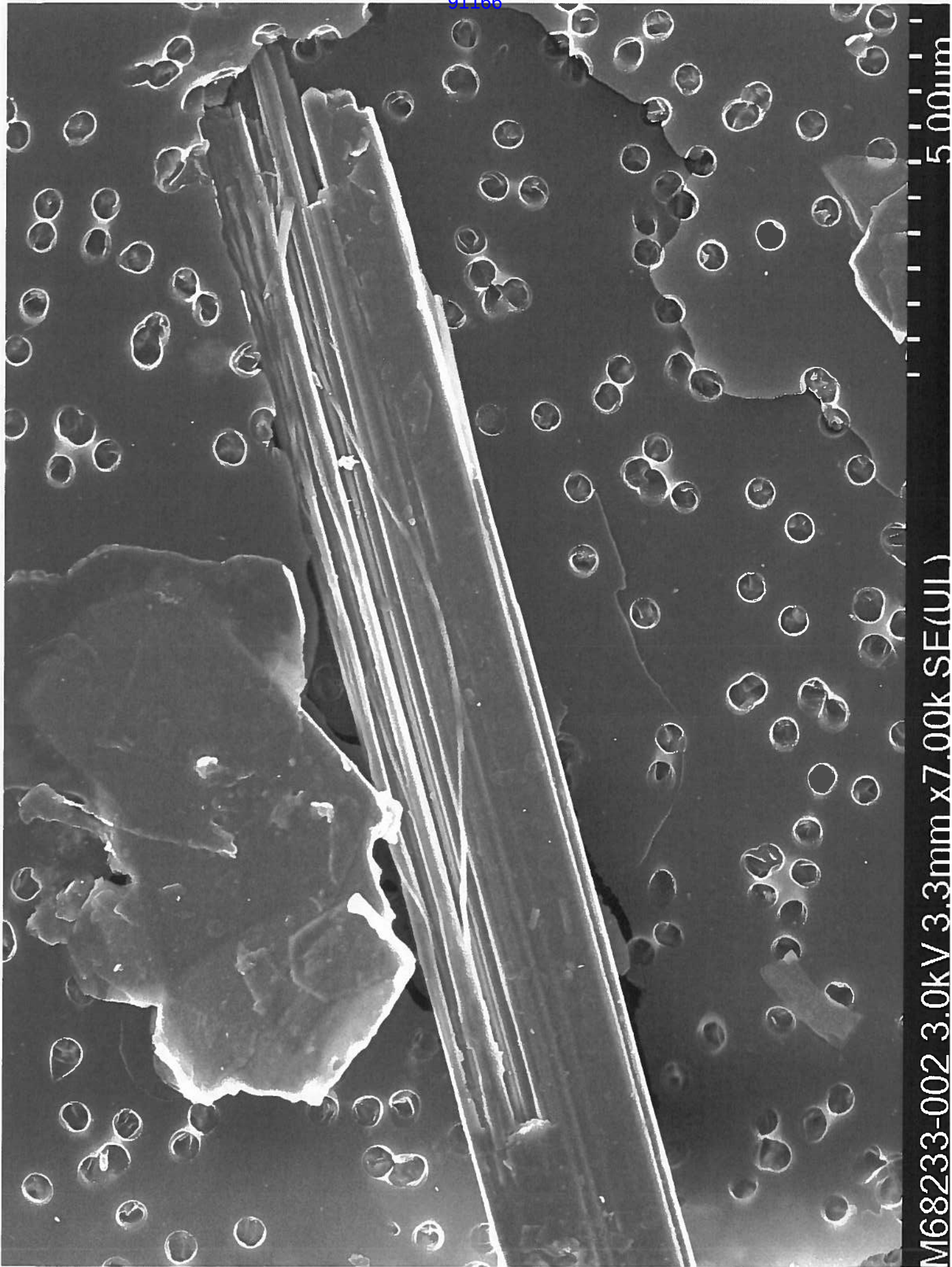


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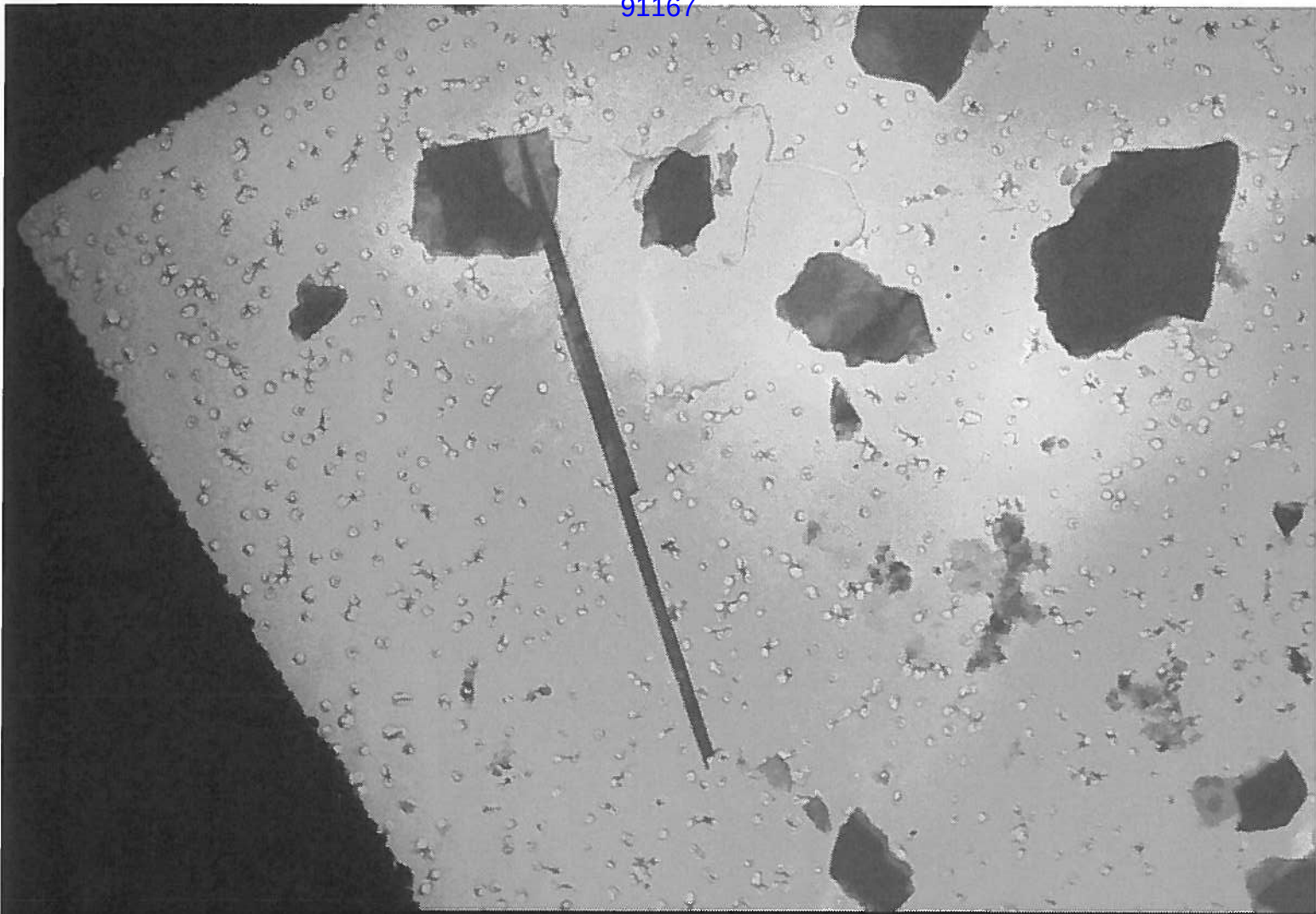
M68233-002-002 Ferro-Anthophyllite (16.4 um x 2.6 um)

2/15/2018





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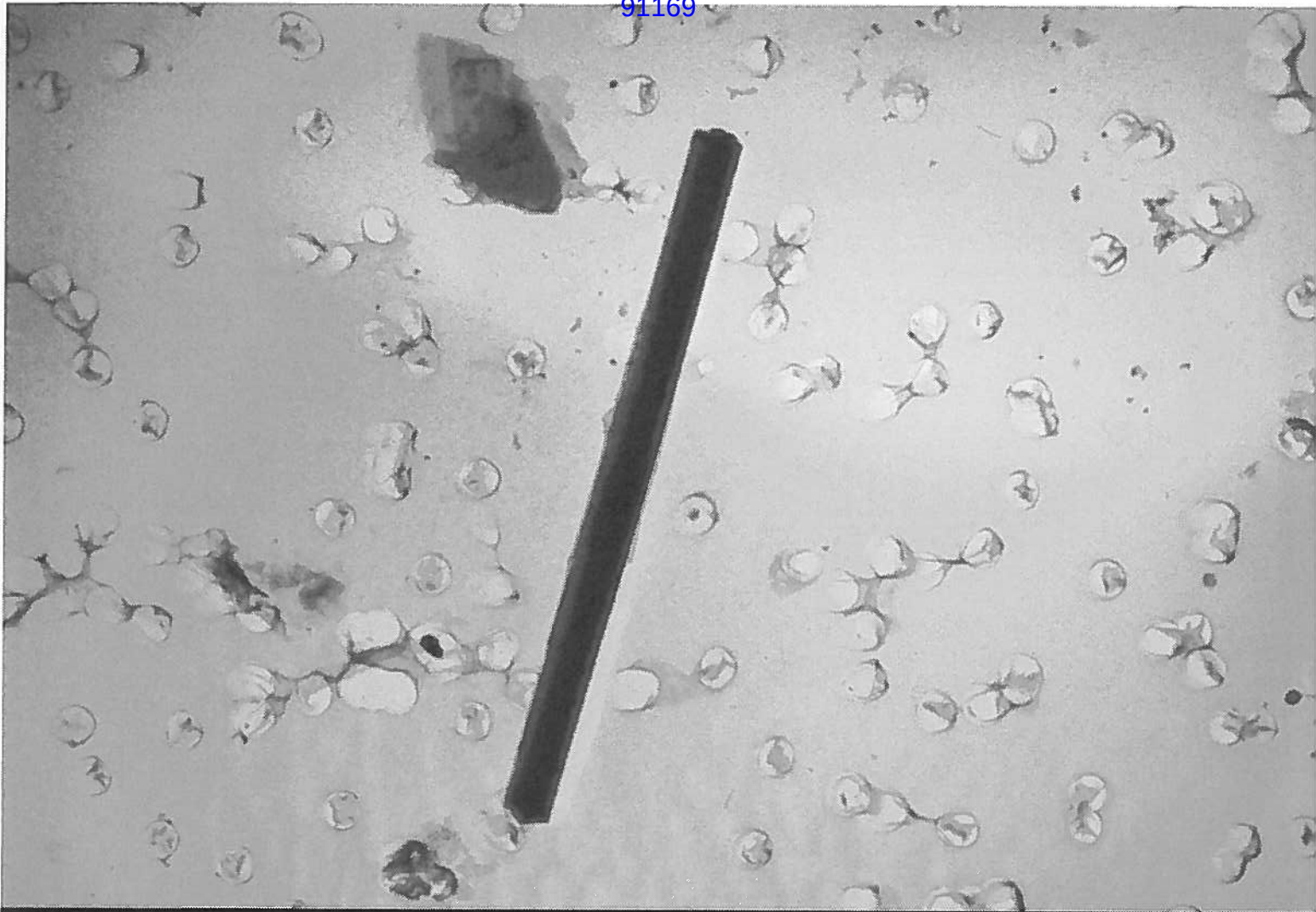
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10.0µm

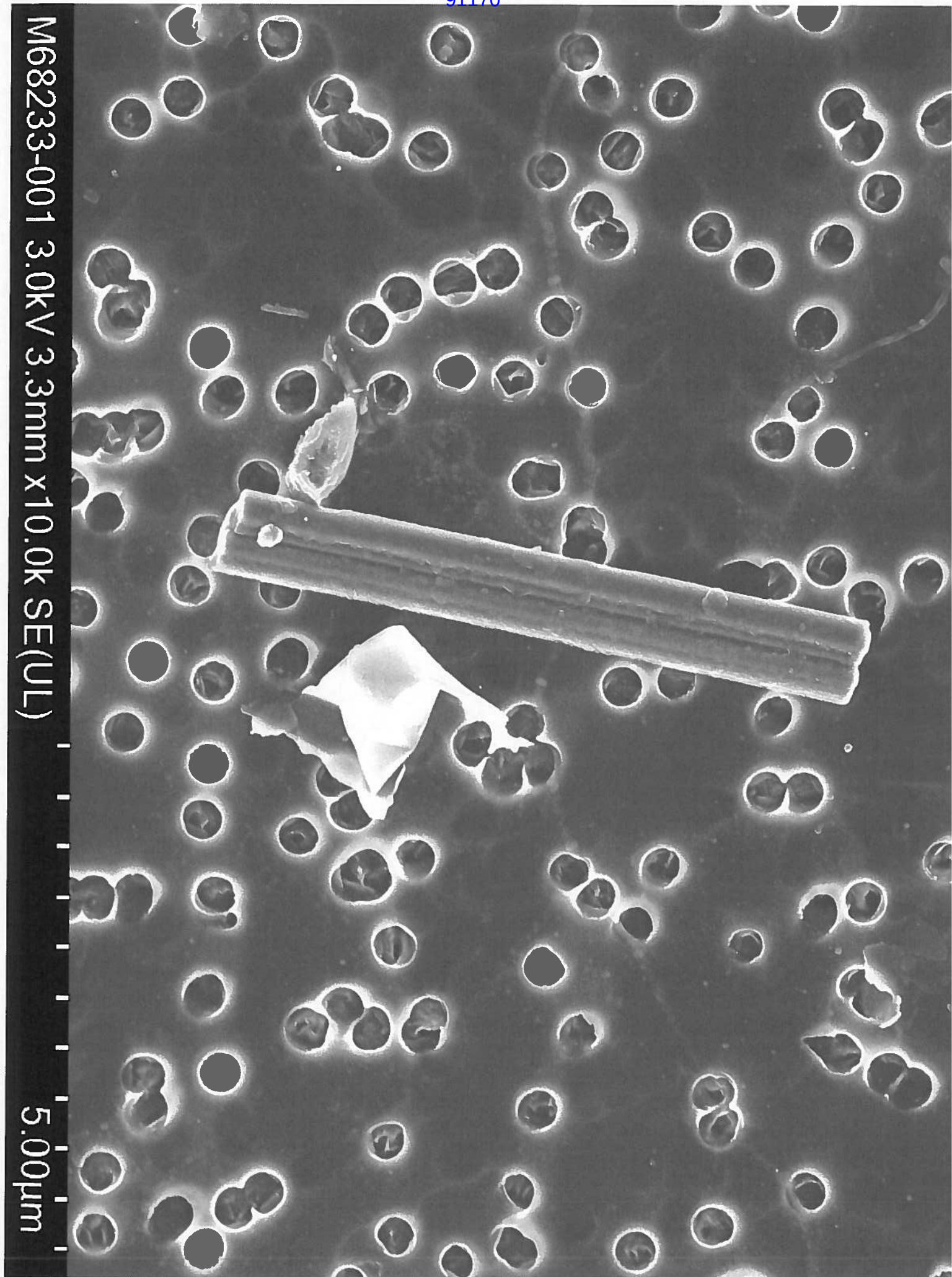


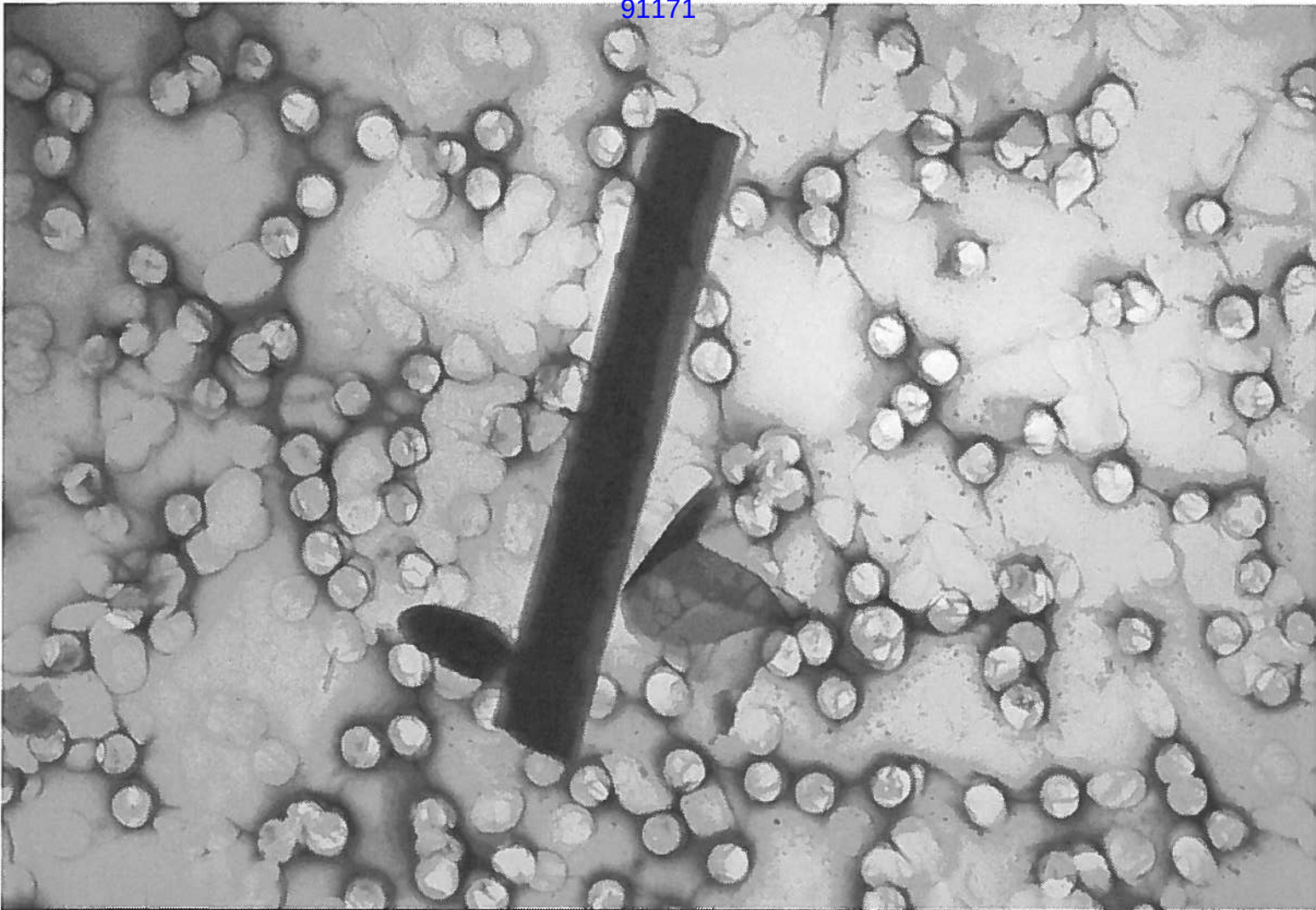


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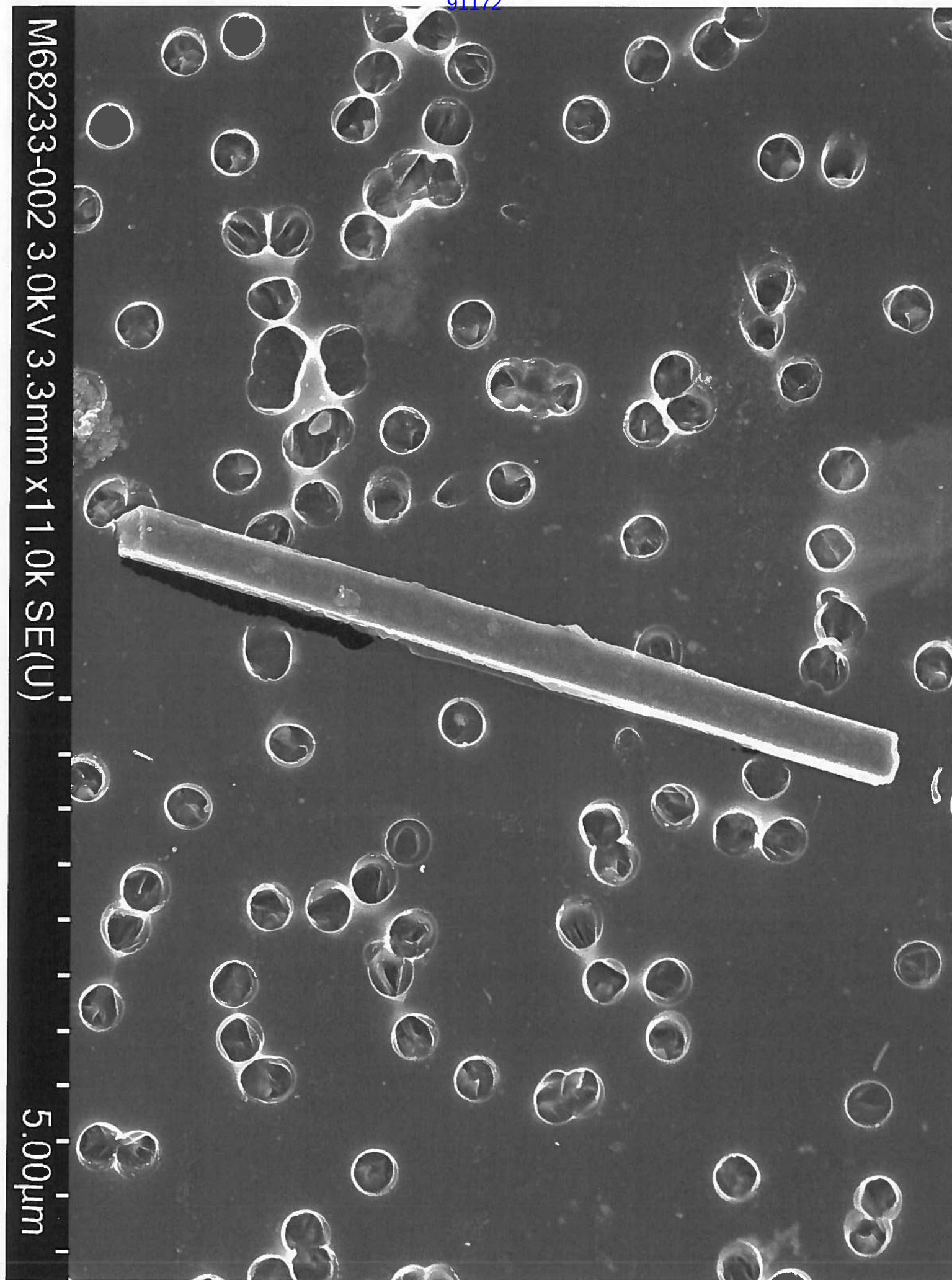




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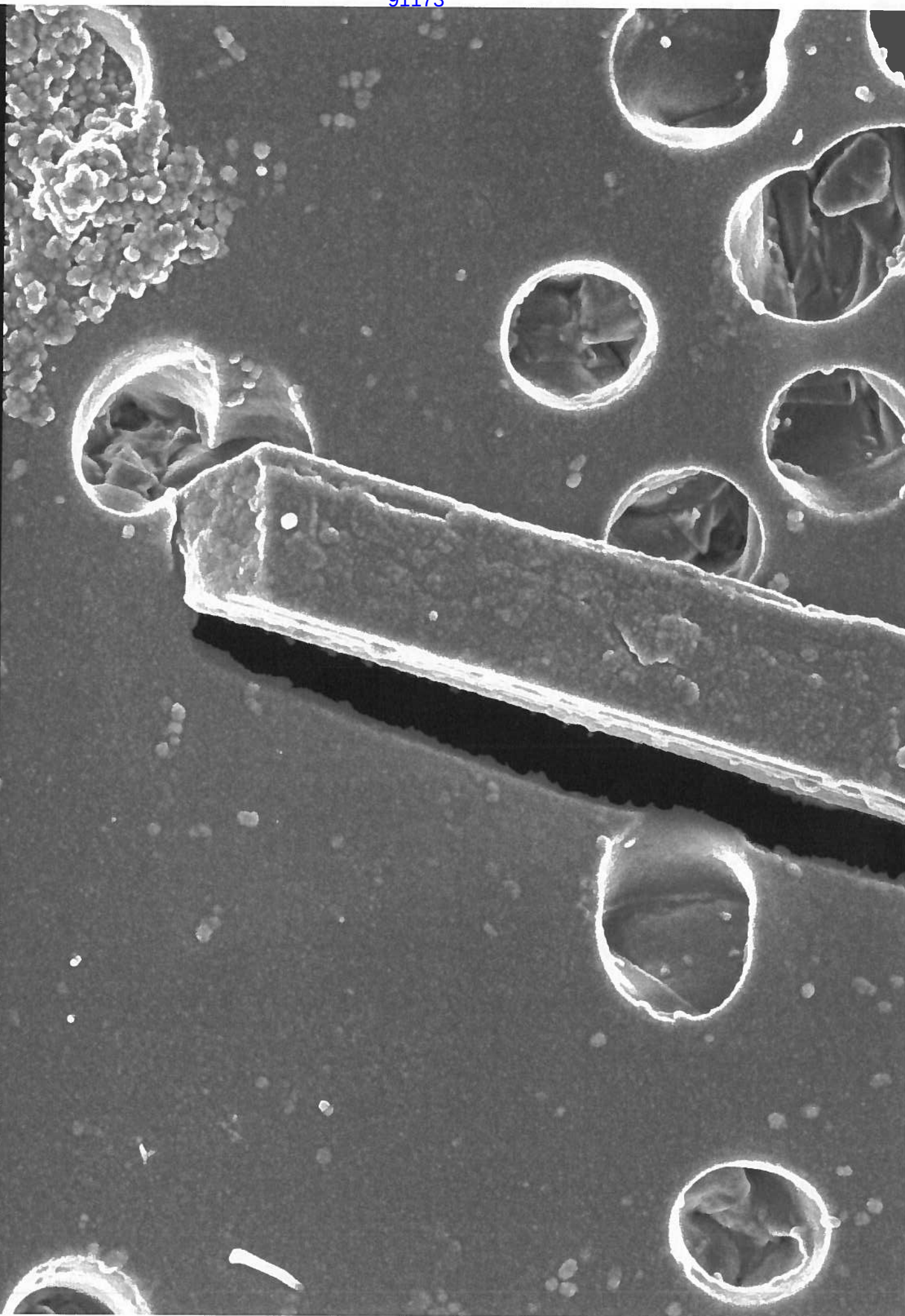
M68233-001-001 Ferro-Anthophyllite (6.8 um x 0.9 um)

2/14/2018



M68233-002 1.0kV 3.3mm X35.0k SE(U)

1.00µm



THE ASBESTIFORM AND NONASBESTIFORM MINERAL GROWTH HABIT AND THEIR RELATIONSHIP TO CANCER STUDIES



A PICTORIAL PRESENTATION

April, 2003

The Asbestiform and Nonasbestiform Mineral Growth Habit and Their Relationship to Cancer Studies

Kelly F. Bailey, CIH
Manager, Occupational Health
Vulcan Materials Company
Birmingham, Alabama

John Kelse
Corporate Industrial Hygienist
Manager, Risk Management Dept.
R. T. Vanderbilt Company
Norwalk, Connecticut

Ann G. Wylie, PhD
Asst. President and Chief of Staff
Professor of Geology
University of Maryland
College Park, Maryland

Richard J. Lee, PhD
President
R. J. Lee Group, Inc.
Monroeville, Pennsylvania

The recognition and regulation of asbestiform and nonasbestiform minerals is of critical concern to the entire mining and aggregates industry, to individuals exposed to these materials and to the economic vitality of the United States.

CONTENTS

INTRODUCTION	1
WHY IS THIS DISTINCTION IMPORTANT?	2
REFERENCE EXHIBITS	
1. What is Asbestos?	4
2. Macroscopic Raw Ore Comparisons	8
3. Light Microscopic Comparisons	10
4. The Aspect Ratio and Particle Width	12
5. Byssolite	16
EXPOSURE EXHIBITS	
ASBESTOS EXPOSURES	
A. Libby Montana Vermiculite	18
B. Greek Tremolite	20
C. Korean Tremolite	22
D. Addison/Davis - Tremolite (Jamestown)	24
E. Addison/Davis - Tremolite (Swansea)	26
F. Smith - Tremolite FD-72	28
G. Stanton - Tremolite 1 and 2	30
ASBESTIFORM AND/OR HIGHLY FIBROUS	
H. Cook/Coffin - Ferroactinolite	32
I. Smith - Tremolite FD-31	34
J. Addison/Davis - Tremolite (Italy)	36
COMMON NONASBESTIFORM EXPOSURES	
K. Homestake Gold Mine	38
L. East Mesabi Range - Taconite	40
M. N.Y. State Tremolitic Talc	42
N. Smith - Tremolite FD-275-1 and McConnell - Tremolite 275	46
O. Wagner - Tremolite (Greenland)	48
P. Addison/Davis - Tremolite (Dornie)	50
Q. Addison/Davis - Tremolite (Shinness)	52
R. Pott - Actinolite	54
SUMMARY	56
CONCLUSION	58
REFERENCES	59
APPENDIX I - Asbestiform Definition Contributors and Supporters	64
APPENDIX II - Analytical Issues	65

INTRODUCTION

It has long been recognized that the inhalation of excessive asbestos fibers, over time, is associated with significant pulmonary disease in humans. The link between asbestos, lung cancer and mesothelioma is well established. Asbestos is perhaps the most feared mineral risk and certainly is among the most publicized, litigated and studied.

Despite this attention, a clear understanding of what asbestos actually is remains a source of confusion to many. This is often demonstrated when commercial asbestos is not known “a priori” to exist in a dust exposure. Nowhere is this problem better demonstrated than the decades old confusion over the difference between asbestiform and nonasbestiform crystal growth.

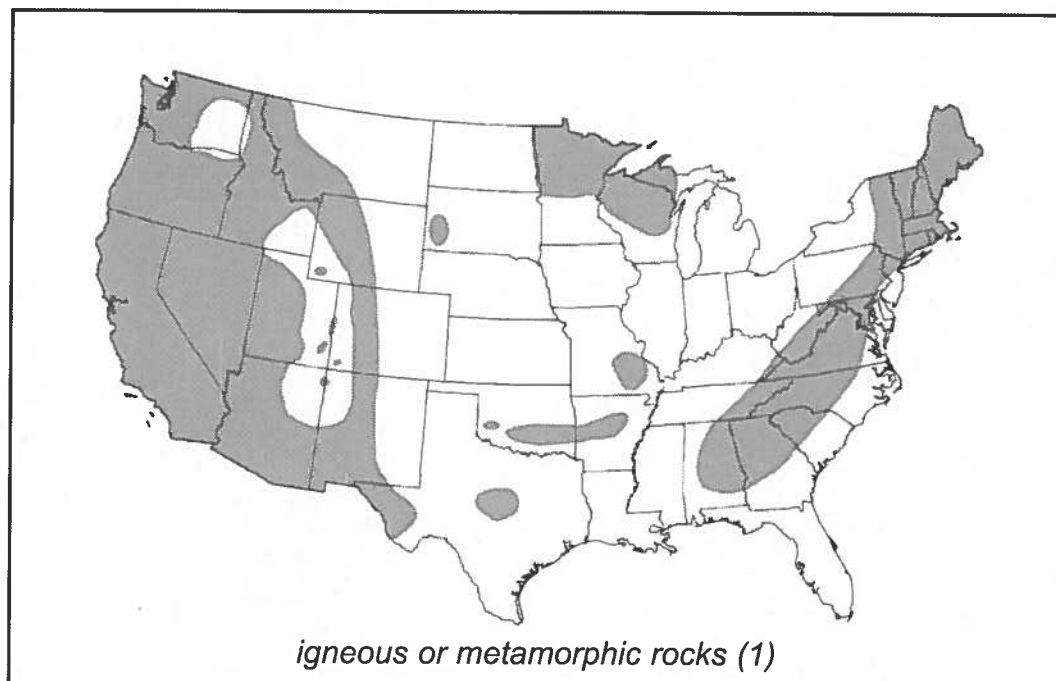
No federal regulatory agency treats elongated nonasbestiform mineral particulates as asbestos, yet some in the regulatory and health community believe that they should. These individuals mistakenly believe that the essential difference between nonasbestiform minerals and asbestos is not significant from both a mineralogic and biologic perspective.

This pictorial presentation demonstrates that important mineralogic and health differences do, in fact, exist. Health researchers who fail to understand these differences can assign and have attributed the carcinogenic effects of asbestos exposure to nonasbestiform minerals. Because these common, nonasbestiform rock-forming minerals make up so much of the earth’s crust, it is important that this error be avoided.

WHY IS THIS DISTINCTION IMPORTANT?

The nonasbestiform minerals are common hard rock forming minerals found throughout the earth's crust. Unlike asbestos, they are not at all rare.

The map below shows the general areas in the continental United States where igneous and metamorphic rocks are likely to be found on or near the surface. Amphiboles and serpentine, the two mineral groups that contain mineral species that may form asbestos, are restricted in their occurrence to these types of rock. When amphiboles and serpentine form part of the bedrock, they may also be found in the overlying soil. All the rock and soil in the shaded areas, however, do not contain amphibole and serpentine, and the occurrence of the asbestiform habits of these minerals in the shaded areas is even more restricted. The shaded areas do not mean that every rock or soil mass in that area contains these minerals, but it does mean that they are often present in these areas.



The composition of the rock also affects the likelihood of finding asbestos. Asbestos is more likely to form during the metamorphism of limestone, mafic and ultramafic rocks and alkali igneous rocks than during the metamorphism of other common rocks such as granite and sandstone. Furthermore, many of the amphiboles, particularly those that contain a significant amount of aluminum, never form asbestiform fibers. Therefore, while the nonasbestiform habits of amphibole and serpentine are common throughout the shaded areas, asbestos occurrences are localized and uncommon.

The U.S. Bureau of Mines reports that the regulation of nonasbestiform minerals as asbestos would significantly impact the mining of important mineral commodities such as gold, copper, iron, crushed stone, sand, gravel and talc. Downstream users of these mineral commodities such as construction, refractories, smelters, ceramics and paint manufacturers, would be affected as well (2).

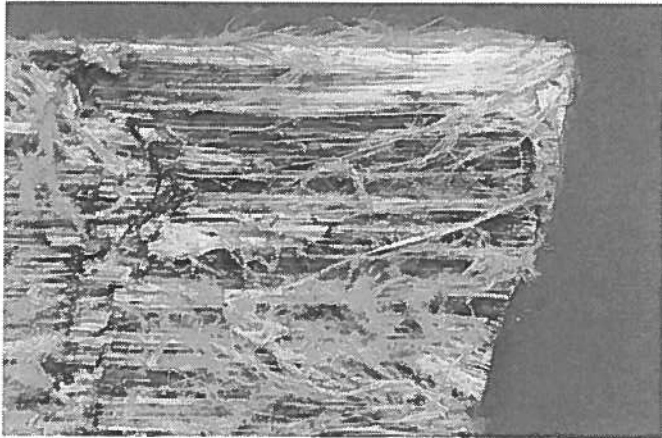
Therefore, it is important that these nonasbestiform minerals be properly assessed with respect to their health risk.

The goal of this document is to clearly and succinctly demonstrate that mineralogical and biological differences exist between asbestos and common nonasbestiform minerals. To accomplish this objective, this presentation:

- **DESCRIBES THE MINERALOGICAL DIFFERENCES BETWEEN ASBESTIFORM AND NONASBESTIFORM MINERALS.**
- **CLARIFIES THE MINERAL EXPOSURES CITED IN KEY HEALTH STUDIES.**
- **SUMMARIZES THE OUTCOME OF THIS COMPARISON.**

REFERENCE EXHIBIT 1

What is Asbestos?



In the *Glossary of Geology*, asbestos is defined as. . .

“A commercial term applied to a group of highly fibrous silicate minerals that readily separate into *long, thin, strong* fibers of sufficient flexibility to be woven. . .” (3).

This definition has been further expanded based on mineral-crystallographic studies over the last decade or so:

- A. ASBESTOS** - A collective mineralogic term that describes a variety of certain silicates belonging to the serpentine and amphibole mineral groups, which have crystallized in the asbestiform habit causing them to be easily separated into long, thin, flexible, strong fibers when crushed or processed. Included in the definition are: chrysotile, crocidolite, asbestiform grunerite (amosite), anthophyllite asbestos, tremolite asbestos and actinolite asbestos. The nomenclature and composition of amphibole minerals should conform with International Mineralogical Association recommendations (Leake, B.E., *Nomenclature of Amphiboles*. American Mineralogist. Vol. 82, 1019 - 1037, 1997).
- B. ASBESTOS FIBERS** - Asbestiform mineral fiber populations generally have the following characteristics when viewed by light microscopy:
1. Mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 μm ,
 2. Very thin fibrils, usually less than 0.5 μm in width,
 3. Parallel fibers occurring in bundles, and
 4. One or more of the following:
 - a) Fiber bundles displaying splayed ends,
 - b) Matted masses of individual fibers,
 - c) Fibers showing curvature

This definition represents the consensus of a group of mineral scientists, several of whom have published extensively in this area (see Appendix I).

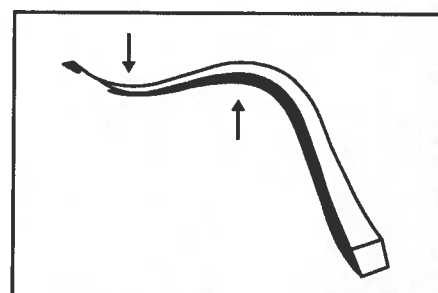
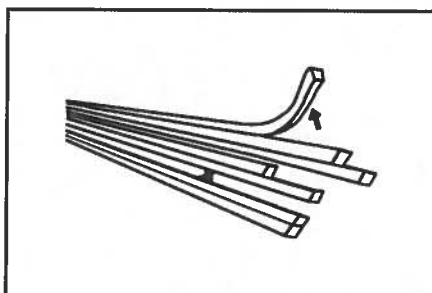
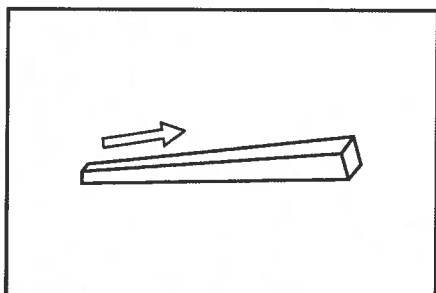
Morphological properties are difficult to apply to single particles when classifying them as a cleavage fragment or a fiber. Distinctions on morphology are most reliably made on populations. Furthermore, in air and water samples, in which particles are often less than 5 μm in length, the presence of asbestos should be verified in bulk material at the source before identification of particles as asbestos can be reliably made. Bulk materials display the full range of distinctive morphological characteristics, but in fibers collected from air and water, the range of morphological properties is more limited.

Asbestiform fibers normally exhibit anomalous optical properties that are distinctive. For example, under polarized light microscopy, asbestiform fibers may display parallel extinction in all orientations, they may display oblique extinction in some orientations at angles that are less than those characteristic of ordinary amphibole fragments in the same crystallographic orientation, they may have only two principal indices of refraction (as opposed to the expected three), or they may display orthorhombic optical properties when monoclinic optical properties are expected (79).

When asbestiform fibers are found in nature, there may be other habits of the same mineral inter-grown such as the brittle, fibrous nonasbestiform habit byssolite and fragments of the enclosing rock (cleavage fragments). Byssolite is characterized by wide, single glassy crystals usually $> 1 \mu\text{m}$ in width. While asbestos is characterized by high tensile strength which results in difficulty on grinding with a mortar and pestle, byssolite and cleavage fragments will easily reduce to powder under the same circumstances (see page 16, Reference Exhibit #5).

Although asbestiform crystal growth is very rare in nature, under the right geologic conditions approximately 100 minerals may be formed in this manner - not just the six minerals we refer to as asbestos (76). Evidence on the carcinogenicity of asbestiform minerals that are not asbestos is mixed, but there is no compelling evidence that all asbestiform minerals are carcinogenic. Different minerals have different biodurabilities, surface chemistries, friabilities in vivo, and bioavailability differences that influence their biological activities (77). Asbestiform richterite, winchite and erionite are examples of fibers that appear to pose a risk similar to that of asbestos (74,78). In contrast, asbestiform talc (72) and minerals such as xonotlite (commonly found in an asbestiform habit but is water soluble) do not appear to pose the same risk.

ASBESTIFORM



In the asbestiform habit, fibers grow almost exclusively in one direction and exhibit narrow width (on the order of 0.1 μm). Fibers that are visible to the eye are bundles of individual crystal fibers known as “fibrils”. In some deposits, there is a range in fibril width, sometimes extending up to as much as 0.5 μm . Asbestiform fibers wider than 1.0 μm are always bundles of fibrils. Asbestiform minerals have fibrils that are easily separated, although variability exists. In populations of asbestiform fibers, the distribution of particle widths will reflect single fibrils as well as bundles of fibrils. Under the light microscope, this “polyfilamentous” characteristic of fibers is evident, and **is the single most important morphological characteristic of the asbestiform habit**. Asbestiform fibers are flexible and exhibit high tensile strength. The flexibility may be accounted for by the very narrow widths of fibrils and perhaps by the ability of fibrils to slide past one another on bending.

Six minerals have been regulated as asbestos. These are listed below:

ASBESTIFORM VARIETY (Asbestos, CAS No. 1332-21-4*)

SERPENTINE GROUP

chrysotile

(CAS No. 12001-29-5)

AMPHIBOLE GROUP

crocidolite

(CAS No. 12001-28-4)

grunerite asbestos (amosite)

(CAS No. 12172-73-5*)

anthophyllite asbestos

(CAS No. 77536-67-5*)

tremolite asbestos

(CAS No. 77536-68-6*)

actinolite asbestos

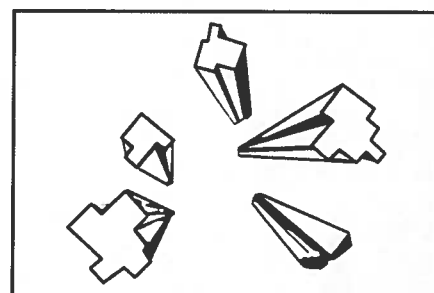
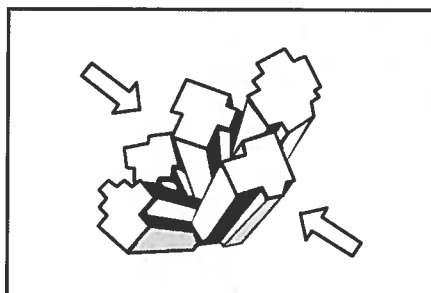
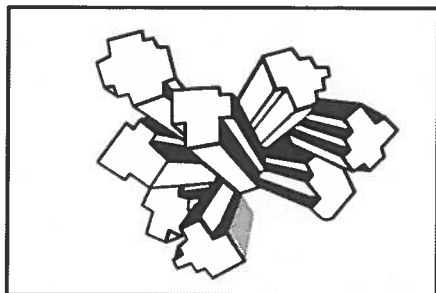
(CAS No. 77536-66-4*)

The presence of an asterisk (*) following a CAS Registry Number indicates that the registration is for a substance which CAS does not treat in its regular CA index processing as a unique chemical entity.

For asbestiform fibers to grow, there must be mineral rich fluids that are either associated with regional metamorphism or contact metamorphism around crystallizing igneous bodies. The vast majority of the occurrences of asbestos are small because, in addition to metamorphic fluids, there must be open spaces into which the fibers can grow, a condition restricted to the upper portions of the earth's crust in structurally specific environments such as faults, joints, the axes of folds, etc. Only rarely are large portions of a rock composed of asbestos.

The most common occurrence of asbestos is in cross-fiber or slip fiber veins. In the former, the fiber axes are perpendicular to the walls of narrow openings in the host rock; in the latter, they are parallel. Asbestos rarely occurs as mass fiber bundles in which fibrillar growth is in many directions. This growth pattern is not clearly related to planar structural features of the rock.

NONASBESTIFORM



In the nonasbestiform variety, mineral crystal growth tend not to grow with parallel alignment, but form multi-directional growth patterns instead. When pressure is applied, the crystals fracture easily, fragmenting into prismatic particles called cleavage fragments. Some particles or cleavage fragments are acicular or needle-shaped as a result of the tendency of amphibole minerals to cleave along two dimensions but not along the third. Stair-step cleavage along the edges of some particulates is common. Serpentine have a single cleavage direction and single crystals would form sheets when crushed. Serpentine rock, when crushed, will produce some elongated fragments.

Comminution of nonasbestiform amphibole produces particles that, although generally elongated, have widths larger than asbestos fibers of the same length. These wide widths are characteristic of all amphibole cleavage fragments, even those that have developed higher aspect ratios due to well-developed parting. Byssollite, the most acicular, needle-like nonasbestiform amphibole, will break perpendicular to the fiber axis during comminution because it is brittle, thereby producing particulates with low aspect ratios (See Reference Exhibit 5).

NON-ASBESTIFORM VARIETY

SERPENTINE GROUP

antigorite

(CAS No. 12135-86-3)

AMPHIBOLE GROUP

riebeckite

(CAS No. 17787-87-0)

grunerite

(CAS No. 14567-61-4)

anthophyllite

(CAS No. 17068-78-9)

tremolite

(CAS No. 14567-73-8)

actinolite

(CAS No. 13768-00-8)

Exhibit 99

COLORADO SCHOOL OF MINES RESEARCH INSTITUTE

A Procedure to Examine Talc for the Presence of
Chrysotile and Tremolite-Actinolite Fibers

Prepared for

Johnson & Johnson
501 George Street
New Brunswick, New Jersey


By

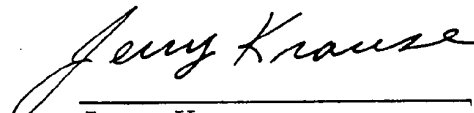
Colorado School of Mines Research Institute
Golden, Colorado

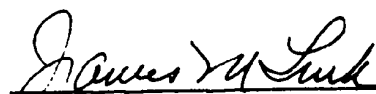
Project C10704

December 27, 1973

APPROVED:


Herman Ponder
Director


Jerry Krause
Senior Scientist
Mining Division


James M. Link
Director
Mining Division

COLORADO SCHOOL OF MINES RESEARCH INSTITUTE

CONTENTS

	<u>Page</u>
Introduction	1
Objective	2
Summary and Conclusions	3
Discussion	4
Details of the Procedure	4
Samples	4
Separation Details	4
Microscopy	6
Tremolite-Actinolite	7
Chrysotile	8
X-Ray Diffraction	8
Appendix	

INTRODUCTION

The purpose of this document is to report the methods used at the Colorado School of Mines Research Institute for detection of chrysotile and/or tremolite-actinolite in samples predominantly composed of talc. The methods described herein have evolved over a period of time, with the aid of suggestions from many individuals, and are frequently subjected to review.

As the impurity level becomes very low ($\ll 1\%$), it is necessary to examine increasingly larger amounts of sample in order to detect the impurity. As a result of the requirement to detect the proverbial "needle in a haystack," we have evolved a procedure which preconcentrates the impurities prior to examination. The net effect is that a large initial sample is fractioned in order to reject the majority from further examination.

OBJECTIVE

The objective of this work was to develop a procedure to screen talc for the presence of chrysotile and tremolite-actinolite asbestos minerals. Based on past experience with detecting and identifying minerals when present at low levels, a concentration of the phases to be detected was considered essential to the success of any suggested procedure. Once concentrated the impurities could be detected by conventional methods of examination.

SUMMARY AND CONCLUSIONS

A procedure to detect the presence of chrysotile and/or tremolite-actinolite fibers in talc is presented. The procedure involves two heavy liquid separations to concentrate any chrysotile and tremolite-actinolite which may be present. The heavy liquid concentrates are examined by optical microscopy for the presence of optical size (greater than approximately 2 microns in length) fibers of chrysotile and/or tremolite-actinolite. The procedure is capable of detecting fibers present at a level of approximately 10 ppm or less.

DISCUSSION

DETAILS OF THE PROCEDURE

The optical and physical properties of talc, chrysotile, and tremolite-actinolite important to their separation, concentration, and identification are listed in the table on the following page.

The separation and concentration technique involves heavy liquid separations and is therefore dependent upon specific gravity differences. Identification of the phases thus separated and concentrated is based upon their optical and morphological properties. It is estimated that the following procedure will allow the detection of chrysotile and/or tremolite-actinolite when each is present at a level of approximately 10 ppm or less.

Samples

This method may be applied to a variety of samples ranging from raw ore to final metallurgical concentrates. Raw ore samples should ideally be crushed and sized to -200+325 mesh to liberate talc and other minerals. Metallurgical process samples containing a large proportion of -325 mesh material can be handled in the same manner although the centrifuging and filtering times will be increased.

Separation Details

Five-gram samples are added to each of two 125-ml separatory funnels which contain approximately 75 ml of heavy liquid (2.90 sp gr).⁽¹⁾

(1) Centigrav; commercially available from American Mini-Chem Co., Corapolis, Penn., 15108.

Relevant Optical and Physical Properties
of Talc, Chrysotile, and Tremolite-Actinolite⁽¹⁾

	Optic Sign	Optic Orientation	Refractive Indices			Specific Gravity	Morphology
			α	β	γ		
Talc	(-)	$\begin{cases} Z \wedge a \cong 10^\circ \\ X \cong b \end{cases}$	1.539-1.550	1.589-1.594	1.589-1.600	2.59-2.83	Plate Fiber ⁽²⁾
Chrysotile	(-)	X = C	1.532-1.549	--	1.545-1.556	~2.55	
Tremolite- Actinolite	(-)	$Z \wedge c = 10-21^\circ$	1.599-1.688	1.612-1.697	1.622-1.705	3.02-3.44	Fiber

(1) Data from Deer, Howie, and Zussman, Rock Forming Minerals, vol. 2, 1962; vol. 3, 1963.

(2) Fiber -- any material having a form such that it has a minimum length to average maximum width of 3:1.

Each sample is well dispersed by thorough shaking of the loaded stoppered funnels, and then centrifuged at 800 rpm for two intervals of 1/2 hr. The float material is agitated slightly between centrifuge intervals to aid in releasing high specific gravity particles which may be trapped in the tightly packed floating fraction. The heavy and light fractions are collected separately on 0.45 μ millipore filters, washed with ethanol or isopropyl alcohol, dried, and carefully weighed. The heavy fraction (sp gr >2.90) will be examined for tremolite-actinolite.

The light fraction (sp gr <2.90) collected above is reprocessed in an identical manner in a liquid of sp gr 2.65. The light fraction with sp gr <2.65 will be examined for chrysotile. The fraction with sp gr >2.65 and <2.90 is assumed to be predominantly talc and therefore is not subjected to further examination. This fraction could of course contain fragments of other minerals locked to the talc.

The 2.65 sp gr liquid is prepared by diluting Certigrav 2.90 sp gr liquid with n, n dimethylformamide having a specific gravity of 0.95. The heavy liquid can be recovered from the alcohol-n, n dimethylformamide washings by extraction with large volumes of water.

The fractions recovered from the heavy liquid separations generally amount to 20 mg or less.

Microscopy

Optical examination of the heavy liquid separates for the presence of fibers is a sensitive examination method. Optical microscopy can detect fibers with a length greater than approximately 2 μ , when present at a level

of approximately 0.1% or greater. If optical examination at magnifications up to approximately 625X does not reveal the presence of fibrous particles, the sample can be passed as being clean. If fibrous material is detected optically, then specific identification of the fibers must be attempted. Optical identification is difficult and subject to numerous errors, especially when working with small particles which are near the resolution limit of the microscope. Electron microscopic examination employing selected area electron diffraction and/or x-ray emission spectrography may be required in order to specifically identify small fibrous particles.

The following optical identification schemes require a great deal of expertise, and are subject to errors introduced by small particle size, the presence of talc fibers, plates lying on edge thereby appearing to be fibers, overlap in optical properties, and variable reaction of chrysotile to the iodine stain.

Tremolite-Actinolite

The heavy liquid separate having a sp gr >2.90 is mounted in immersion oil of refractive index 1.600 for transmitted light examination under a petrographic microscope. All amphiboles have refractive indices appreciably greater than 1.600 and will be readily visible. All observations are made at magnifications of 125X and 250X. Single particles are occasionally examined at a magnification of 625X. Tremolite-actinolite fibers are identified by having length to width ratios greater than or equal to 3:1; refractive indices greater than or equal to 1.600; and extinction angle varying between 10° and 21°.

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Metadata

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Exhibit 100

TF
PROPOSED SPECS FOR ANALYZING
TALC FOR ASBESTOS

Johnson & Johnson

F

New Brunswick, N.J.
May 16, 1973

Subject:

Dr. F. R. Rolle

I am going to England Friday, May 25. I have been asked to bring along our proposed specs for analyzing talc for "asbestos."

Please get me copies of all reports, correspondence, etc., that are pertinent, plus a cover memo outlining our recommendations.

England is considering method of preconcentrating the asbestos so as to be able to analyze by X-ray. They find no "asbestos" by doing this with Italian talc. They find (Pooley) 0.05% of a tremolite-type in Vermont.

T

T. H. Shelley

mf

c: Dr. R. A. Fuller
Dr. A. J. Goudie
Dr. W. Nashed
Dr. D. R. Petterson

RECEIVED
MAY 18 1973
W. NASHED
JOHNSON & JOHNSON

Johnson & Johnson

New Brunswick, N.J.

May 22, 1973

Subject: PROPOSED SPECS FOR ANALYZING
TALC FOR ASBESTOS

Dr. T. H. Shelley

I. USP

II. Other Methods

Step Scanning X-Ray Diffractometry

Advantages

Disadvantages

Preconcentration of Asbestos (Pooley Method)

Differential Thermal Analysis

Microscopy

Electron Microscopy and Petrology

Dispersion Staining

III. Present Strategy

F. Robert Rolle

F. Robert Rolle, Ph.D.

ab

cc: Dr. A. J. Goudie
Dr. G. Hildick-Smith
Dr. W. Nashed ✓
Dr. D. R. Petterson

RECEIVED

MAY 23 1973

W. NASHED
JOHNSON & JOHNSON

- 1 -

I. USP

We have been working on a preliminary draft with Mr. George Heinze on developing a USP method for the detection of asbestos in talc. Exhibit A is the USP XIX comment proof on X-ray diffraction. Exhibit B is our detailed procedure which has been submitted to Mr. Heinze, for determination of amphibole (such as, tremolite) and serpentine (such as, chrysotile) in talc by scanning X-ray diffractometry. Using this method on Italian Talc used in SHOWER TO SHOWER* Powder, we find a level of detectability of 1% for Tremolite and 5% Chrysotile.

II. Other Methods Which Have Been or Are Under Consideration
for the Detection of Asbestos in Talc

Step Scanning X-Ray Diffractometry

Advantages: Level of detectability better than by scanning X-ray diffraction. For example, by this method we can detect 0.1% tremolite and 3% chrysotile in Italian talc (Exhibit C).

Disadvantage: Using the step scanning procedure, it takes one day per sample for analysis vs. a small fraction of a day for the scanning method.

*A Trademark of JOHNSON & JOHNSON.

- 2 -

Preconcentration of Asbestos followed by X-Ray Diffraction
Analysis (Pooley Method)

Dr. Pooley has developed two techniques for preconcentration of chrysotile and tremolite in talc followed by X-ray diffraction analysis. For chrysotile (Exhibit D), his level of detectability is 0.05% and when this method is applied to Italian and Vermont talc, no chrysotile is detected. The second technique developed also by Dr. Pooley involves preconcentration of tremolite in talc (different procedure) followed by X-ray diffraction analysis. This technique has not been written up yet, but evidently when applied to Vermont talc, 0.05% of tremolite-type is found. The limitation of this method is that it may be too sensitive.

Differential Thermal Analysis (DTA)

DTA has proven to be a relatively fast and sensitive method (at least 1%) for detection of chrysotile in talc (Exhibit C). The DTA method is not applicable for the detection of tremolite in talc. At our suggestion, the FDA recently purchased a DTA unit, presumably to look into this method for detecting chrysotile.

- 3 -

Microscopy

A. Electron Microscopy and Petrology

The areas of electron microscopy and optical microscopy (petrology) have been thoroughly evaluated, but though, not without merit, they suffer from the following limitations:

- a) require a fair degree of expertise
- b) in the case of electron microscopy, we are dealing with an expensive instrument that few laboratories have.
- c) one is viewing a very small amount of material (μg) under the microscopy and one wonders how representative it is of the bulk material. Multiply sampling and viewing under the microscopy may eliminate this problem, but it results in consumption of a great deal of time.
- d) the level of detection really depends upon the amount of time spent with the microscope.
- e) quantification by particle counting is very time consuming and normally not done.

B. Dispersion Staining

The dispersion staining method championed by Dr. Walter McCrone looked initially very exciting as a quick, easy method for scanning talc for asbestos. However, it was found (Exhibit E) that certain non-asbestos minerals gave the same dispersion staining characteristics as the asbestos minerals. The method evidently lacks specificity when applied to talc.

- 4 -

III. Present Strategy

Present plans call for scanning X-ray diffraction for the detection of both amphibole and serpentine asbestos in talc. In the case of chrysotile (serpentine), Differential Thermal Analysis may be a good alternate method since it offers a level of detectability of 1% chrysotile in talc vs. 5% chrysotile in talc by scanning X-ray diffraction.